VOL-V NO-5

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

GENERAL LIBRARY
JAN 10 1920
UNIV. OF MICH.
Engineering Library

NOVEMBER 1919

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

That "Something" in Non-Gran

FOR years, manufacturers have analyzed NON-GRAN bronze bushings—have made up castings following the Non-Gran formula from A to Z. Yet, they have been unable to discover that "something" that puts Non-Gran on a plane above the commonplace bronzes—that "something" which makes Non-Gran resist wear two or three times longer than the ordinary run of bronzes.

There is no secret about Non-Gran. We simply build into it the personality and experience resultant from 11 years' concentration making one alloy by one formula, one method, and, consequently, with one result—a wear-resisting bronze of unvarying uniformity, free from flaws, sand holes, air or gas pockets.

Locomobile, Mercer, Stearns, Stutz, Haynes, Kissel and scores of other well-known cars, trucks, tractors and motors are bushed with Non-Gran exclusively.

The builders of these reputable machines buy on proof, not claims. They know, by test and use, that Non-Gran is the "best buy" in bearing bronze. You can safely take their word and follow their "lead."

Write for the Non-Gran booklets and list of big manufacturers who use and endorse Non-Gran Bearing Bronze.

AMERICAN BRONZE CORPORATION
Berwyn Pennsylvania

District Offices

348 Tremont Bldg. . . . Boston, Mass.
481 People's Gas Bldg. . . Chicago, Ill.
2010 Woolworth Bldg. . . . New York.
340 Leader-News Bldg. . . Cleveland, O.
Pacific Coast Allied Industries, Inc.
870-882 Minna St., San Francisco, Cal.
340 Azusa St., Los Angeles, Cal.
1262 1st Ave., So., Seattle, Wash.

Foreign Distributors

Foreign Dept., Automotive Products Corp.
2010 Woolworth Bldg., New York, N. Y.
Stanley J. Watson
Sheen Road, Richmond, London, Eng.
Aktiebolaget Galco
18 Norra Bantorget, Stockholm, Sweden.
Cycle Motor Trade Supply Co.
Capetown and Durban.
Henderson & Co.
Johannesburg, South Africa.
John O'Neill Pty., Ltd.
Sidney, Australia.
Sucrs. De L. Villamil & Company
Porto Rico.
Simson & Nielson, Copenhagen, Denmark.

HIGH SPEED
NON-GRAN
BEARING BRONZE

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. V November, 1919 No. 5

THE 1920 ANNUAL SOCIETY MEETING
NEW YORK CITY, JANUARY 6-8

WITH the year 1920 looming large upon our horizon, there is speculation as to what benefits this year may hold in store and bring to us. At this time, when plans are being made for the proper direction of the activities just ahead, there is evidence of a certain poise is every quarter. It is at just such a time that consideration is given each year to the problems of automotive engineering in connection with the Annual Meeting of the Society.

Our automotive problems this year are even more serious and pressing than in the past, and with all the present uncertainty in the business world there is even greater need for counsel, consulation and discussion. Not only is this true, but the mind is tempted to conceive new needs and new tendencies of the immediate future. In the midst of this search for solutions and better methods there comes this opportunity to get together, to compare and to analyze future requirements bearing upon present-day automotive engineering developments.

The annual meeting of the Society, Jan. 6 to 8, during Automobile Show Week, at New York City, provides the necessary common meeting ground for engineers and executives engaged in the automotive industries and activities more or less connected with the trade. With the compelling attractions of New York at this season for the busy executive and engineer, the Annual Meetings of the Society of Automotive Engineers are becoming in effect a great and enthusiastic rally of the Society's membership, from every section of the country.

This year gives promise of the greatest Annual Meeting every held, and with hotel congestion more acute than ever, all members have been advised to make sure of their accommodations well in advance.

Timely Papers to Be Presented

Timely papers will be presented at the Annual Meeting treating subjects of pressing importance. Busy engineers have been persuaded to prepare papers for the benefit of the members and every opportunity is being provided for spirited discussion of them. The Meetings Committee especially desires that members come prepared to engage in the discussions of the various papers to be delivered at the professional sessions of the Society, to be held Jan. 7 and 8.

Adapting Engines to the Use of Available Fuels, printed in this issue of THE JOURNAL on page 345, is the title of a paper by J. G. Vincent. This deals in a preliminary way with gas engine fuel characteristics and is elaborated by detail information relating to design in which these characteristics have been determining factors. Closely related to the preceding paper is Bettering the Efficiency of Existing Engines by H. C. Gibson which offers practical suggestions and possible solutions of raising engine efficiency by adapting them to the new conditions imposed from time to time by changes in fuel specifications. Any practical methods of increasing the efficiency of engine operation by the adaptation of present engines and by new designs, are certain to react favorably on the industry by broadening the field of their utility.

To just what extent aluminum pistons enter into the engineering requirements of each type of engine used in the several automotive fields, is yet undetermined. It is very certain, however, that E. G. Gunn, backed by an extensive experience in the design, manufacture and performance of aluminum pistons, will submit data of considerable value in his paper, Aluminum Pistons, for the consideration of those attending the meeting.

Other papers of far-reaching importance are those by P. S. Tice, Thomas Midgley, Jr., and a representative of the Bureau of Standards, dealing with data relating to engine design available only through use of the high-speed indicator. It is expected that these indicators will be demonstrated on an engine and the indicator card projected upon the screen and showing how the pressure varies with changing conditions of fuel and in other ways. There will be the added attraction of an opportunity for examining these newly developed indicators. It is also expected that some of the papers prepared for the symposium on Combustion of Hydrocarbon Fuels by Dr. H. C. Dickinson, C. F. Kettering, H. L. Horning, Donald McKenzie and Mr. Honoman will be based upon details of phenomena first observed by aid of the high-speed indicator. There is apparently agreement upon the need of a better understanding of the underlying facts concerning the combustion of engine fuels. One of these papers will describe laboratory methods employed for measuring the rate of flame propagation in engine cylinders and will discuss the relation which flame propagation bears to the performance of automotive engines. There will be discussions along similar lines so that much data will be disclosed in connection with these matters.

The subject of Mixed Fuels is to be made the

theme of a discussion of considerable present and future importance. It is likely that much new information regarding fuels will be brought out by the discussion, with the probability of practical suggestions along lines by which future investigations may be directed.

Mixture Requirements of Automobile Engines by O. C. Berry associate professor of gas and automotive engineering, Purdue University, deals with research on carburetion and settles several mooted points bearing upon carbureter design. Thermodynamics of Automotive Carburetion by C. F. Hopewell is a theoretical discussion of many problems encountered in carbureter research and development.

Closely related to the foregoing papers on research is the paper, Supercharging Engines and Superchargers by Major G. E. A. Hallett. The description and information given are of particular interest to the aeronautical engineer, inasmuch as they give indication of new conditions of aircraft design involved in the use of a supercharger, the function of which is to supply the engine with combustible mixture at undiminished pressure at all altitudes.

Lubrication Research by G. A. Kramer will include a discussion of crankcase dilution, presenting figures representing the effect of various quantities of diluent in different grades of fuel on the viscosity of crankcase oils and an analysis of several possibilities for preventing or minimizing the effects of crankcase dilution.

A paper dealing with research on Springs and Spring Suspensions by Dr. Benjamin Liebowitz describes a seismograph designed for spring suspension research and shows how, from a curve traced by this instrument, quantities can be accurately measured which are of primary importance in the design of springs. A paper by E. Favary dealing with Principles Underlying the Design of Springs and Spring Suspensions, will point out the advantages and disadvantages of present types. New methods will be suggested for overcoming these disadvantages and attention will be directed to probable future improvements.

In addition to the discussion of springs it is expected that an excellent paper, based upon the results of many years of successful custom-body designing and manufacturing, will be presented by a prominent engineer. It is likely that this paper will bring out many new facts bearing upon body building that will be applicable to the years just before us.

Social Affairs

There will be a departure from the conventional affair of last year in that the reception and dance for members, ladies and guests will be replaced by a Carnival Night, Wednesday, Jan. 7, at the Hotel Astor. On this occasion every opportunity will be afforded members to become better acquainted and at the same time to enjoy the novelties of the entertainment and the attractions of dancing. The committee in charge promises a continuous program full of action and fun, calculated to appeal strongly to each person attending. Because of the limit placed upon the attendance, members are urged to return the application ticket blanks promptly so as to insure admission to the Carnival.

A big S. A. E. dinner, the largest in the history of the Society, will be held in the ballroom of the Hotel Astor, Thursday, Jan. 8. There is every reason to believe that the full capacity of nearly 1500 covers will be required.

The speakers at this dinner will include members and others popular with the membership. John Kendrick Bangs, much in demand as a toastmaster, will serve the Society this year in that capacity. Provisions have been made to reserve seats in the balcony for ladies desiring to hear the speeches.

To all members who have not already reserved their dinner and hotel accommodations, we say, *now is the time to do so.*

Adapting Engines to the Use of Available Fuels

By J. G. VINCENT[1] (*Member*)

ANNUAL MEETING PAPER *Illustrated with* DRAWING AND CHART

PROBABLY the most absorbing topic today in the automotive engineering world is the fuel question. This is as it should be, for it is essential that we design engines which will utilize not only the fuel that is being sold today but also the fuel which will be on the market two or more years hence. There has hitherto been an entire lack of cooperation between the men who determine what kind of fuel is to be marketed and the engineers who design the car to use this fuel. This is obviously wrong. It is time that we devise some system which will insure the realization of the entire useful life of the cars we are designing today, rather than have them discarded or run under adverse conditions when the quality of the fuel deteriorates. Furthermore, we must recognize that the character of the fuel must change if the automotive industry is to expand in the future as it has in the past. The petroleum resources of the country are already taxed to the limit to supply sufficient gasoline for the cars now in use, and the only apparent way in which this fuel supply can be materially increased is by utilizing some of the heavier fractions which at the present time are not considered fit for automotive use, or possibly by an extension of the various cracking processes, some of which have shown considerable promise.

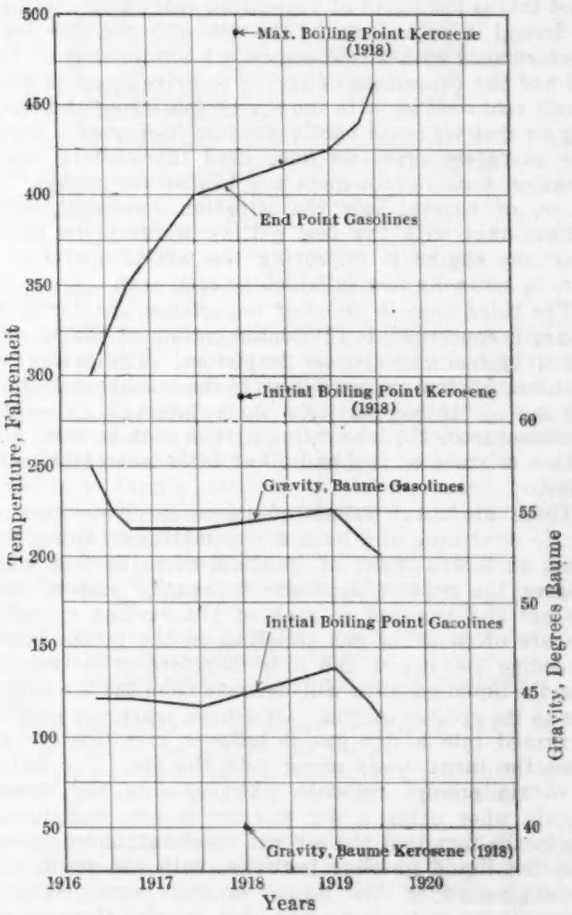
The accompanying curves are intended to bring out some of the salient facts in regard to the character of the fuel marketed in the past few years. Of course, there is no one quality in a fuel that can be considered by itself as controlling its suitability for automotive use. Only three characteristics which are of special interest have therefore been plotted, although many additional considerations are to be borne in mind. It will be noted that the end-point of the average gasoline has been rapidly ascending in the last four years and is now but little less than the end-point of the kerosene of today. The gravity, Baumé, readings are slowly descending but the initial boiling point has not undergone much change. As long as this latter condition holds we shall not have much trouble in starting engines in cold weather, but the use of a tight-fitting choke will become more and more of a factor in determining how quickly the engine will fire, since at low temperature we can volatilize only the lighter constituents of the fuel, and as the percentage of these lighter constituents in relation to the whole goes down, we must get a larger amount of gasoline into the cylinders to have enough of the lighter constituents to start combustion.

A point I would like to impress upon you is the desirability of having our experimental cars running today on a fuel that will be the equivalent of fuel to be generally marketed two years hence. Thus far lack of cooperation between the fuel producers and refiners and the automotive industry has prevented a forecast of fuel characteristics such as to enable car designers to design engines to handle properly the fuel available.

[1]Vice-president in charge of engineering, Packard Motor Car Co., Detroit, Mich.

MEETING THE FUEL PROBLEM

Let us now examine various methods of meeting the fuel problem. There was a time when we pointed with pride to the frost on a bare aluminum intake header, considering this a very desirable symptom indicating perfect vaporization. This applied when we were dealing with fuels of about 80 deg., Baumé, which vaporized under the conditions obtaining in the manifold at ordinary temperatures. The low temperatures produced by this vaporization increased the volumetric efficiency of engines very materially and cold headers were therefore looked on with favor. Thus we have repeatedly demonstrated on Liberty engines that 500 hp. or more can be developed by one of these engines, which normally will give about 420 hp., by using high-test gasoline and getting the mixture into the cylinders cold enough. But nowadays we are dealing with fuels which refuse to



VARIATIONS IN GASOLINE FROM 1916 TO 1919, INCLUSIVE, BASED ON DATA OBTAINED FROM GASOLINE PURCHASED IN CARLOADS

vaporize at ordinary temperatures in the header. In the course of some experiments with glass manifolds I found that when using 56-deg. Baumé gasoline it is necessary to put the mixture into the cylinders at about 180 deg. fahr. to secure a perfectly dry mixture. Of course, this is going to the extreme, and for all practical purposes the mixture can be somewhat wet and yet the engine will function properly. We will therefore assume that a mixture temperature of 120 deg. fahr. is the minimum to be used.

I would like to state some of the reasons why the mixture should be introduced in as dry a condition as possible. From the standpoint of the driver the item first in importance is that of spark-plug fouling. Repeated experiments have shown that such fouling in the great majority of cases is not due to over-oiling, as commonly supposed, but to the presence of wet fuel on the plug which in connection with the small amount of carbon that is formed on the porcelain apparently has the property of making the surface a sufficiently good conductor to enable the high-tension current to leak over the surface of the porcelain rather than jump the gap. Clean oil is a good insulator, and when a plug does not fire because of oil, this is due to the fact that the oil acts as an insulating material between the electrodes. If the mixture is introduced into the cylinders in a dry state and does not condense afterward, it is obvious that no wet fuel will appear on the porcelain. Practical experience of many months on several cars has shown that this is the secret of preventing spark-plug fouling.

Second in importance to the driver is the question of performance with a cold engine. I believe that we have all had the experience of trying to drive a car in excessively cold weather with the engine sputtering and coughing so that we could hardly get into high gear. During the past few years we have used thermostats, water-jacketed headers, hot-spots and heated air intakes. All these, of course, help the situation somewhat, but I believe that with the fuel getting worse more rapidly than the engine is improving the winter operation of cars is becoming less satisfactory each year.

The third item in order of importance, insofar as the owner is concerned, is the contamination of the lubricating oil by fuel which passes the pistons. This is a serious problem, for few owners will go to the trouble of draining off the oil at compartively short intervals in winter. In consequence the lubricating system soon becomes filled with a mixture of fuel and oil of little or no lubricating value.

There are many minor questions involved when we try to distribute and burn a wet mixture. Many have tried numerous types of intake headers to find which insures the nearest approach to equally proportioning the air and gasoline to each of the various cylinders. We are often using gas velocities in the intake header exceeding 100 m.p.h. and it is therefore to be expected that the liquid gasoline will separate from the air stream, due to its greater inertia. Of course, when the gasoline is turned into a dry gas it behaves just like air and takes the turns nicely along with the air. The failure to obtain prompt response when opening the throttle quickly when using a wet mixture is also undoubtedly due to the fact that the air will accelerate more quickly than the liquid gasoline particles, with the result that the engine either "lies down" or spits back. When a dry mixture is used we can step on the throttle and get instant response. The more finely divided the gasoline, the better the engine responds. It is conceivable that a finely atomized mixture of liquid gasoline and air can be made to perform as well as a dry mixture, but it is one thing to produce a finely atomized spray of gasoline and another to maintain the gasoline mist in this condition until it is fired.

Securing a Dry Fuel Mixture

I take it that we are now all agreed that a dry mixture is desired. There remain to be examined the various methods of obtaining this result. The commonest one now employed is to utilize some of the heat contained in the exhaust gases, and since there is expelled in the exhaust from 20 to 40 per cent of the heat units contained in the original gasoline, depending upon the engine speed and other considerations, it would appear that this is the most practical and economical way to obtain the result. Theoretically it undoubtedly is, but practically, in some cases, the method presents serious objections. If we assume that the intake and exhaust manifolds are in some manner constructed integrally, it is obvious that the temperature of the intake walls will vary in proportion to that of the exhaust walls. This, of course, means that at high speed and under heavy load the walls will be very much hotter than at low speeds and light loads. It is therefore obvious that if the intake header is sufficiently hot to do the job at low speeds and light loads, it will be altogether too hot at high speeds and heavy loads to obtain the maximum volumetric efficiency of the engine. Of course, there are many cases where a high volumetric efficiency under heavy loads or at high speeds is not essential, so that this solution gives pretty fair results. We are all, however, striving to get the most power possible out of the least engine, and it certainly hurts to cut 10 or 20 per cent off the maximum output of the engine to insure a dry mixture at low throttle and light loads.

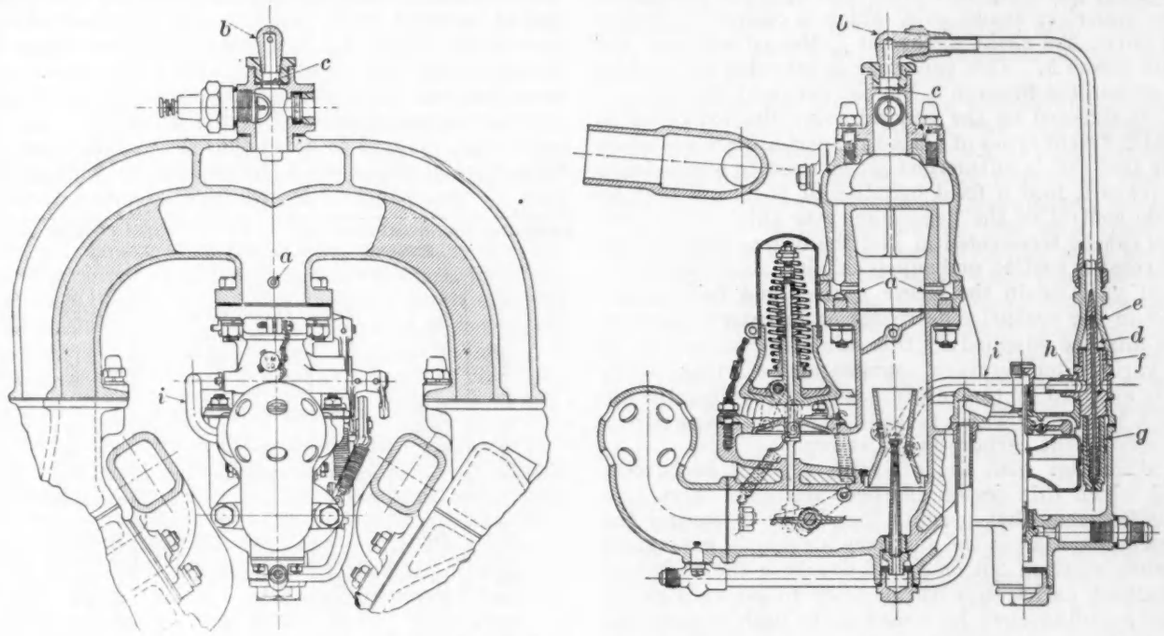
Then again there are various compromise schemes most of which are based on the theory that it is possible to locate a very hot spot at such a point that the heavy particles of the fuel will be thrown against this surface and vaporized, whereas the air and the lighter particles will be diverted from the hot-spot by the particular design of the header. This would be fine if it were possible to get the hot-spot hot enough under low throttle conditions. It is undoubtedly a good compromise scheme and does not detract from the volumetric efficiency of the engine to the extent that the regular exhaust-jacketed job does.

We now come to electrical means of supplying the heat necessary for vaporization. To illustrate the impracticability of this solution let us make a few assumptions which will represent a hypothetical case. What we want to find out is how much heat it is necessary to supply to a header to insure a reasonably dry mixture under average driving conditions. Assume an hourly gasoline consumption of about 2 gal. or about 12½ lb. Assume that this gasoline is of 56-deg. Baumé gravity and that its latent heat of vaporization is 150 B.t.u. per lb., this figure varying according to different authorities, and the pressure under which vaporization takes place but being sufficiently accurate for our purpose. Assume an air temperature of 40 deg. fahr. and that it is necessary to put the mixture into the cylinders at 120 deg. fahr., which is far from being a dry mixture, but experience has shown that this is sufficiently dry to eliminate most of the troubles which I have enumerated. Assume also a rather rich mixture, say about 13 to 1; this will give us about 162 lb. of air to combine with

the 12½ lb. of gasoline. The specific heat of air is 0.1689 and of gasoline 0.51, so that to raise the gasoline and air from 40 to 120 deg. fahr. and completely vaporize the fuel requires:

	B.t.u.
Latent heat of 12½ lb. of gasoline	1,875
Heat to raise 162 lb. of air 80 deg. fahr	2,189
Heat to raise gasoline 80 deg. fahr	510
Total	4,574

To supply 4574 B.t.u. per hr. electrically is equivalent to the consumption of about 1.34 kw. per hr. which in turn would be represented by a current consumption of 223 amp. at 6 volts. These calculations of current consumption, of course, assume 100 per cent efficiency on the part of the electrical heating system which, obviously, it would be impossible to attain. It will therefore be seen that the electrical solution does not appear very promising in view of the high current required. It is also evident that this heat cannot be supplied to the intake header by the circulating water unless a header be designed with a great deal of radiating surface in contact with the water, and even this would give very slow heating-up conditions although a thermostat were employed.



ELEVATIONS, PARTLY IN SECTION, OF A MANIFOLD DEVELOPED TO SOLVE THE FUEL PROBLEM

ANOTHER SOLUTION OF THE PROBLEM

It was these various considerations that led me to look elsewhere for a solution of the problem. It appeared desirable to evolve some simple inherently automatic method of supplying the heat, not possessing any of the disadvantages cited above. It was shown that about 4574 B.t.u. per hr. would represent an average requirement. Assuming that there are 19,000 B.t.u. in 1 lb. of gasoline, it will be seen that we could secure the necessary heat from the complete combustion of 0.24 lb. of gasoline per hr., providing we could attain a 100 per cent heat transfer. We do not, of course, obtain 100 per cent efficiency with the scheme I am going to describe, but I believe that from a thermal standpoint you will agree that it is a very efficient arrangement or one representing but very small heat losses. The principle of this device is to take advantage of the difference in pressure existing on either side of the carbureter butterfly-valve and cause a small amount of the combustible mixture to pass through a passage which is in parallel with the main carbureter passage, burn this mixture in a suitable burner and then allow the burnt gases to mix with the incoming main supply to the engine above the throttle. It was evident immediately that this general scheme would be at its maximum efficiency under low throttle and light load conditions; an intense heat is generated very promptly under these conditions, which are obtained when starting up and idling. On the other hand, under wide-open throttle conditions, when we wish to maintain the volumetric efficiency of the engine as high as possible, but very little mixture passes through this "shunt" passage and a negligible amount of heat is produced in the burner. Of course, the reason that the mixture need not be heated for wide-open throttle conditions is that combustion is largely assisted by the increased turbulence, increased compression pressures and naturally higher jacket-water temperature.

There are four main units which combine to give the desired result. They are briefly as follows:

(1) A special inlet manifold which has a water-jacket as well as a combustion jacket
(2) A burner which is attached to the combustion jacket
(3) A vaporizer or miniature carbureter which is used to furnish the mixture for the burner
(4) An auxiliary ignition breaker and coil which is used to furnish the spark for the burner spark-plug

The manifold as shown on the accompanying drawing is of the conventional construction except for the additional jacket used for the hot gas which communicates with the main intake passage through the two hollow "suction" plugs shown at *a*. The burnt gas joins the main mixture after coming through these holes and the

proportions are such that at no time does the burnt gas come into contact with the new mixture at a sufficiently high temperature to preignite the mixture.

The burner body is fastened to the manifold by the two-bolt flange shown, and in the burner body there is formed a combustion chamber into which a spark-plug fitted with a wide gap is inserted, as well as an observation window of heat-resisting glass which permits the action of the burner to be observed at all times. The mixture from the vaporizer is supplied by a ⅜-in. copper pipe and enters the combustion chamber after passing through a calibrated hole in the elbow shown at *b* on top of the burner and a screen *c*. The purpose of the latter is to assist in the atomization and even distribution of the incoming mixture. The mixture is supplied by the vaporizer shown at *d*, which is composed of four main parts, the choke *e*, the jet *f*, the jet sleeve *g* and the air intake *h*. This vaporizer is intended to function as a carbureter through a limited range of depressions. It is constructed on the general principles embodied in several different types of plain-tube carbureters and relies on the fact that a submerged jet exposed to atmospheric pressure will feed a fixed quantity of fuel, and that by suitable control of the depression over this jet the flow of fuel can be accelerated in just the degree required for an increasing suction and supply of air. Accordingly the level of gasoline in the sleeve *g* rises and falls as the suction in the venturi *e* decreases or increases. Control of the mixture supplied by this miniature carbureter to meet various temperature changes and starting conditions is attained by the simple means of coupling the air intake *h* to a pipe *i* which takes its air from the auxiliary air supply of the carbureter, as shown.

In connection with the air-valve type of carbureter around which this device has been designed there is a dash adjustment that permits the driver to control the depression existing in the auxiliary air supply passage so that when starting out on a cold day both the main and the auxiliary carbureters can be made to supply a richer mixture simultaneously by means of the dash adjustment.

The high-tension current for the burner spark-plug is supplied by an independent ignition coil, the primary circuit of which is wired in parallel with the regular ignition circuit; the extra coil is controlled by a separate contact-breaker. The latter is operated by the same cam as the regular engine ignition contact-breaker. It will thus be seen that the burner spark-plug is operating whenever the engine ignition is operating, and in the case of the twelve-cylinder engine there are three sparks in the burner per revolution of the engine. I have not found it advisable to cut off this spark or control it in any way, since except for the small amount of current used by the extra coil there appears to be no disadvantage in allowing it to operate continuously.

How the Device Operates

In actual operation, when the engine is idling, combustion takes place in the burner silently and continuously and a bluish-green flame completely fills the combustion chamber. This flame diminishes in intensity as the throttle is opened and the depression in the main intake header is thereby decreased, the general result being that for ordinary driving conditions up to 25 m.p.h. a mixture temperature of 150 to 180 deg. fahr. is maintained, giving perfect distribution, excellent acceleration, absence of spark-plug fouling and elimination of dilution of the lubricant in the crankcase. At higher speeds and wider throttle opening the influence of the combustion heater gradually decreases until at wide-open throttle it is practically out of action, which is exactly the condition desired. This combination has permitted the running of a twelve-cylinder engine on kerosene at moderate driving speeds with practically the same results as when using gasoline, but when using kerosene there are critical temperatures below which we cannot go without considerable spark knock. The problem of burning kerosene is, of course, something that we do not yet face, but the design of this heater can be modified to permit any shape of temperature-load curve desired. The combustion heater as at present constructed does not permit us to start on kerosene, but simple modifications would permit this to be accomplished.

One question that naturally arises is: What effect has the combustion heater on gasoline economy? I have conducted a great many experiments in an endeavor to answer this question. A series of tests was made on the dynamometer, the results of which are shown in the accompanying table. In these tests the gasoline consumption of the engine and of the burner were measured separately. It will be noted that the consumption of the burner, when idling, was 0.066 gal. per hr. This is slightly over ½ pint per hr. It will also be noted that under average driving conditions the engine fitted with a combustion heater may consume approximately 3 per cent more than one without the heater, but it is possible to save a considerable amount of gasoline under such driving conditions as call for frequent accelerating, owing to the improved performance obtained with a dry mixture. In cold weather and even in hot weather it is possible to run with a much leaner mixture when the mixture is dry, and this will more than offset the slight amount of gasoline which the burner uses. I believe that taking an average over city and country mileage there will be little, if any, difference in the matter of gasoline consumption in moderate weather between a car fitted with a combustion heater and one not so equipped, but that there will be a noteworthy saving in cold weather.

GASOLINE CONSUMPTION OF A 3 BY 5 IN. TWELVE-CYLINDER ENGINE USING COMBUSTION HEATER

Engine Speed, r.p.m.	Equivalent Car Speed, m.p.h.	Brake Horsepower	Gas Consumption, gal. per hr.		Burner Consumption / Engine Consumption	Temperature of Manifold, deg. fahr.
			Engine	Burner		
350	Idle	.....	1.02	0.066	0.064	218
400*	9.5	2.33	1.32	0.054	0.041	210
800*	19.1	5.07	1.80	0.054	0.030	200
1,200*	28.6	10.00	2.40	0.066	0.027	187
1,600*	38.2	16.53	3.30	0.114	0.035	156
1,600	38.2	32.00	4.27	0.102	0.024	150
1,600	38.2	63.00	7.20	0.060	0.008	146

*Assumed average driving conditions.

In conclusion, I would say that it has been demonstrated that, in addition to its other advantages, this device will appeal to both the careless driver who omits to change the engine oil frequently in winter and the careful driver who has hitherto taken this necessary precaution. In the first case it will serve to prevent damage to the engine, which is the result of the poor lubricating qualities of a mixture of fuel and oil, and in the second case it will materially reduce cost of operation.

Airships and Their Commercial Possibilities

By R. H. Upson[1] (*Member*)

Cleveland Section Paper *Illustrated with* Photographs

BEFORE the war airships were not generally considered important. The Zeppelins carried a few holiday tourists at prices ranging between $50 and $100 per passenger for a distance that could be accomplished by train at about one hundredth part of this cost. There were a few little dirigibles in this country at the various county fairs with a single man as operator, the method of control being that the operator ran from one end of the car to the other. In good weather these little ships furnished pleasure to the county fair crowds, but aside from this many thought that the airship would never become a practical means of transportation. Some were daring enough to grant it considerable value for military or naval purposes, but for commercial uses anyone who had dreams along such lines would easily have been dubbed a hopeless visionary.

What an Airihip Is

I think I am not insulting anybody's intelligence by making a more elaborate statement of what an airship is. We have seen one here, but I doubt if very many of you who are engineers in other lines stopped to think what it really is. Suppose we have a rather large motor boat of 6 tons gross displacement that has a speed of 30 m.p.h, which is rather good for that size of boat. It should be understood that this is not a hydroplane, but a displacement type of boat just like any ordinary ship. Let us enlarge this boat in our imagination, keeping it of the same general form and shape and exactly the same weight, but simply enlarging the dimensions. We see it swell and get bigger and bigger. Just continue this idea until the boat is big enough to displace its own weight of air instead of displacing its own weight of water. Then we have an "airship," which I regard as by far the best name for that type of craft. It is not only simpler, but is more sensible and scientifically correct than any other term of which I know.

We have this boat transformed into an airship by simply increasing its size. We ask, "Does not an airship depend upon having a gas balloon?" Of course it does, but the only function of the gas is to fill up space. Hydrogen or helium gas is the nearest approach to nothing that will serve this purpose. This is not news, but I will now tell you something that most of you do not realize. We assumed a certain speed, which was high for our boat. We will also assume, for argument, that the airship developed by enlarging that boat be propelled at the same speed as before. To attain that speed the airship will require only about one-tenth of the power that was previously necessary to propel the same load through the water. This is a fundamental fact that is very little understood or appreciated.

I have already mentioned that the airship has in past years been regarded as almost hopeless for commercial application. There have, of course, been visionaries who thought otherwise; I am speaking of the former general attitude of technical men.

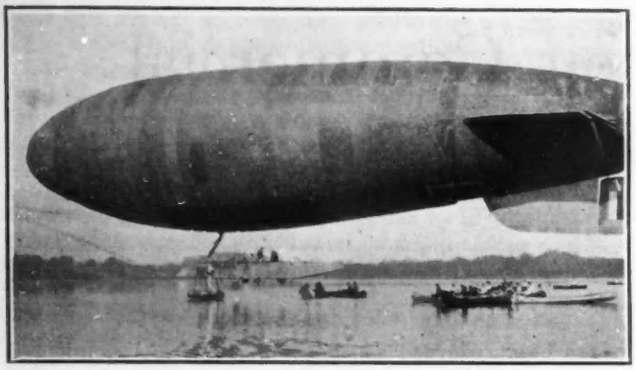
Seven years ago Mr. Vaniman attempted to cross the ocean in an airship, the Akron. He was lost with his crew in an unfortunate accident which I am glad to say has never happened again. Many people felt that this was all that prevented Vaniman from crossing the ocean. It is interesting to speculate on this at a time when more attempts are being made with the same purpose.[2] I will say now without hesitation what has never before received publicity; it was a mathematically proved fact that Vaniman did not have a chance to cross the Atlantic in that dirigible, in spite of its rather large size for that time. It was very slow, attaining only about 30 m.p.h. with all its 300 hp., and did not carry enough fuel to get half way across, yet it was fairly representative of the ships of that date including even the Zeppelins.

Now a great change has come, a wonderful thing has happened. Whereas Vaniman's ship was slow, clumsy and without enough speed to combat the most ordinary winds at sea, today we are ready to predict the brightest kind of a future for airship transportation. Today we have a ship of considerably less than half that size which has amply proved its capabilities of making the transatlantic trip. In other words, if we made a ship today exactly the size of Vaniman's it would have twice the useful load and four times the propulsive efficiency, or a ship of that size could go twice as fast and also twice as far at that speed. I hope you appreciate the stupendous nature of this advance. I am speaking about carrying capacity and efficiency, things that have a definite limit above which we cannot go, and yet these enormous advances have been made. This is what it amounts to; it simply takes the airship out of the defensive state and puts it right "over the top."

When Vaniman died some of us feared that there died with him the chances of successful commercial transportation by an airship, because we could not see our way through the very serious objections that would prevent such a thing. Yet the improvements which have been made in the last few years are so enormous and point the way to so many more in the future that there seems no longer any question as to the final result. We yet have very much to do, but now we can see the way. We can see what is coming and provide for it.

Airship construction is the best example I know in regard to what steady plugging along will accomplish toward improving equipment of which we already knew the fundamentals. The result has not been accomplished by any radically new inventions or any great discoveries in materials. It has been done simply by refinment, by improvement and by steady progress all the way through, and it is so important as indicating still farther future

[1] Aeronautical engineer, Goodyear Tire & Rubber Co., Akron, O.
[2] This paper was delivered before the famous flight of the R 34.



LANDING ON THE WATER WITH AN OLD TYPE AIRSHIP

advances that I will outline the chief lines through which these very large improvements have been effected.

HOW IMPROVEMENTS HAVE BEEN MADE

There are three principal ways in which improvements have been made. I have already mentioned how much we have done in weight saving, approximately doubling the effective carrying capacity of an airship for the same size. That is a small item, however, compared with the others.

The second way, which is far more important than the direct saving in weight, is the improvement of overall propulsion efficiency, or, to pin that down to still narrower limits, decreasing the resistance. This has been one of the most fascinating subjects in the whole history of airship design.

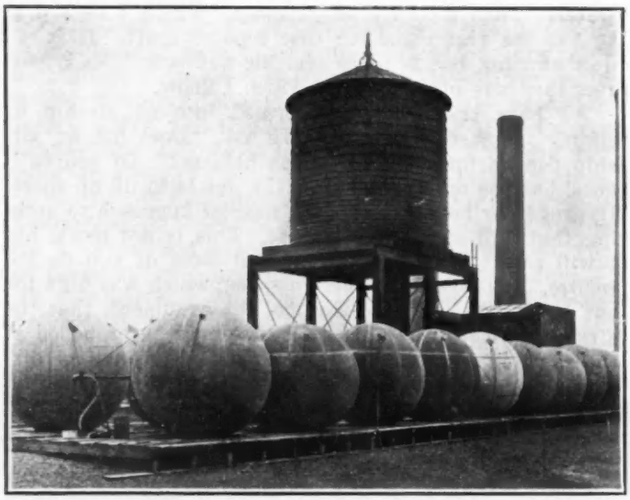
In starting systematic construction and scientific investigation, we discovered the very interesting fact that in the airships of five years ago the envelope or gas bag, which had been only fairly well streamlined, represented only about one-fourth to one-fifth of the total resistance. Without casting any discredit upon the hit-and-miss designers of that day, they commonly used an argument something like this: "Why worry about such details as ropes and rigging when we have such an enormous bag to propel through the air?" But when we make experiments we find that all these little things cause about three times as much resistance as do the big things. The ship we saw today is not of the very latest design, but it is one of the latest. No doubt those of us who saw it close enough thought it still complicated in its rigging, but the ships that we were making two years ago were elaborate compared with this one.

As a matter of concrete illustration I will relate what was done on a particular size of ship. Two years ago we began making ships of 77,000 cu. ft. displacement with 100-hp. engines which gave 38 m.p.h. and in one test nearly 39. The next design took the same engine, propeller and car, except for trimming it up a little. We enlarged the bag to 84,000 cu. ft., 10 per cent larger, and we drove that enlarged bag at 48 m.p.h. with the same engine. This was attained solely by cutting down the parasite resistance. Now 10 m.p.h. may not sound like much, but when we consider that the necessary power increases as the cube of the speed, we appreciate what the relative improvement was. The way to get a straight comparison is to take both ships at the same speed and compare them on the basis of carrying capacity for the same range of action.

Before leaving the subject of resistance, I might give a better idea of why it makes so much difference. I will bring out a little later how marvelously little fuel is consumed in a large airship per passenger or pound carried. For instance, with a ship such as it is possible to build, passengers could be carried across the Atlantic for a gasoline fuel cost of $10 per head. We might say, "Why worry about the fuel if there is so little used?" The great thing about improved efficiency is not the direct saving in fuel cost. That is a mere incidental. The thing that makes the difference is what could be put in place of the fuel if it was not necessary to carry it. That is where the big gain comes.

Let us now consider the third and most important method of improvement. Along the lines of weight saving and resistance saving, we will at some time reach the limit. In this last method we will also reach the limit eventually, but that time is very much farther off. I am referring to the mere effect of an increase in size, which is far more important than anything else we can do. Keep this in mind, because it is true and will be appreciated to some extent before I get through. Given a ship of sufficient size it is practically true that we can do anything with it. If we want speed, we can get it by making the ship big enough; if we want more carrying capacity or altitude, we can get them by increasing the size of the ship. There is a great misconception regarding the effect of size, and I will go into that a little and draw again upon your imagination.

It is frequently stated, as a reason why airships are more effective in larger sizes, that the lift increases as the cube and the weight only as the square, and we get all kinds of beautiful results. I am sorry that I must puncture that explanation, but it is not at all true. The magazine writers who find it so easy to explain the effect of size forget that a modern airship is not like a free balloon. When the size is increased we get more complications, such as an increased head of gas, and everything is increased in proportion so that some of the weights increase not as the square or as the cube, but as the fourth power of the linear dimensions. Many of the important structural elements of airships increase more than in proportion to the increase in lift. If it were not for structural refinement with the increase in size, the structure of airships in the larger sizes instead of being lighter would be definitely heavier per pound of lift, hence we cannot hope to save much on structural



EXPOSURE TESTS OF FABRIC UNDER ACTUAL CONDITIONS OF GAS PRESSURE

weight. As a matter of fact, assuming similar construction, the total fixed weight, aside from powerplant, increases approximately in a constant ratio to the volume. Where we get the advantage is purely and simply from a propulsive or power standpoint. It is simply that the carrying capacity increases approximately as the cube of the dimensions, whereas the power necessary to propel the ship at an equal speed increases as the square. That is the only big advantage of large size airships, but it is so very important that it makes possible all the effects I have mentioned.

Suppose we start with an airship of certain dimensions and double the linear dimensions all the way through with proportionate changes in the structure and design to accommodate the increased size. Let us assume that, everything considered, the useful lift for fuel, passengers and cargo will be increased eight times. The power, however, need only be increased four times to propel the enlarged ship at the same speed. At the same time we need carry only half as much fuel per pound of cargo lifted as in the ship we started with.

TWO OF THE FIRST NAVY BLIMPS BUILT IN THIS COUNTRY AND TWO SPHERICAL TRAINING BALLOONS

This means that we can go the same distance and at the same speed as before and carry eight times the passengers, cargo, etc., and in addition have as a reserve another load equal to the entire weight of powerplant and fuel. We can readily see what possibilities this indicates, because the question immediately arises, "What are we to do with that reserve?" If we want to put in extra passengers we can, or we can put in extra power and get more speed. If we want to carry the same number of passengers at the same speed for longer distances, we can do that; we can then double the previous distance on a non-stop flight. If we want to take the same number of passengers to greater altitudes by loading the ship less heavily we can do so. That is why I say that, given a ship large enough, we can do practically anything with it. Just as an example of speed alone, 100 m.p.h. would not be at all unreasonable for a ship of 10,000,000 cu. ft., provided we had a suitable powerplant.

NEEDS FOR THE FUTURE

Thus airships have been improved within the last few years to such an extent that the future seems at least visible at present. I want to point out now a few things we have to do to make it a reality. I have just hinted at one. We need engines that are better suited to airship work. There are misconceptions on that point which should be cleared up. It is often stated that what is needed is extreme reliability. That is only partly true because the consequences of an engine failure are not nearly so serious as in an airplane and for very obvious reasons. In the first place, large airships will carry multiple powerplants. Of course, large airplanes do this also but they are comparatively limited as to the number of engines they can run on. A dirigible carrying six Liberty engines can run at a fair speed on one of them; thus the matter of reliability from that standpoint is not so important. In a transatlantic trip, even if all the engines fail we still have enough lift to keep up for two days at least, and the problem is not as much extreme reliability as long running. In other words, in an airplane we want an engine to run a few hours and to be absolutely dependable; with a dirigible we want an engine which has a good chance of running 100, 200 or perhaps 500 hr. That is the whole difference. There are a great many other points about a dirigible engine that will have to be developed before we get one that is satisfactory, but I have mentioned the most important thing.

Before airship transportation is really commercially practicable, better fabric must be developed. Fabric is the principal expense at the present time on account of depreciation. Furthermore, big airships of the future cannot and will not be dependent on hangars for ordinary stops. They will be dependent on hangars only for assembly and repairs and periodical inspections. These will be something in the nature of drydocks. That means that the large airship of the future must spend most of its time in the open. Our present fabrics are knocked to pieces very quickly by weather, mostly by sunlight. It is fairly easy to protect a fabric by painting it just as is done on an ocean liner. Did you ever see one when they were not painting it? By the time it is 10 years old it has a coat of paint ¼ in. thick, but with an airship this can hardly be done, because by the time 8 or 10 coats were used over such a huge surface the ship would not fly. The ideal would be to

have the fabric itself resistant to the elements which are so destructive.

I will say without hesitation that rubber is a very poor makeshift for holding gas or resisting the weather. In the first place, the kind of a compound that will hold the gas will not resist the weather, so after putting in a compound to hold the gas we put on another compound to protect it. On the other hand, this protective compound is not good for holding gas. We practically double the weight there and that is only one of the inconvenient features of the present rubberized fabric.

We must also develop better landing facilities. The object of our trip[2] here today was more than anything else to prove that an airship can be landed in a relatively small space, but to do it successfully time after time will require improved equipment. Much yet remains to be done not only as regards the landing but also in the method of "docking" or putting the ships in large hangars for overhauling.

The Discussion

QUESTION:—What does the fabric weigh per yard?

MR. UPTON:—The fabric in this balloon weighs about 14 oz. per sq. yd. It varies in different parts of the balloon.

QUESTION:—How permanent is the gas?

MR. UPSON:—You have to add a little from time to time; it is a matter of management. A poor pilot will waste gas because he will take a ship out when it is full of gas and then ascend to an altitude where he must release a large amount. In the hangar the balloon is often purposely kept full to cut down inward diffusion of air, but with proper hangar equipment it need not be taken out full; only enough gas is needed to reach the altitude desired. Of course, occasionally it must be entirely reinflated unless fresh gas is kept running through, because in addition to slow gas leakage a small amount of air gets in, but this is small compared to the outward loss. The gas loss during a short flight is practically nothing when below the critical altitude, but if on a long trip fuel is being used all the time, and as fuel is consumed 50 times faster than the gas leaks out, the problem is not to stay up but to stay down. Consequently we must often make landings when so light that we can hardly stay down.

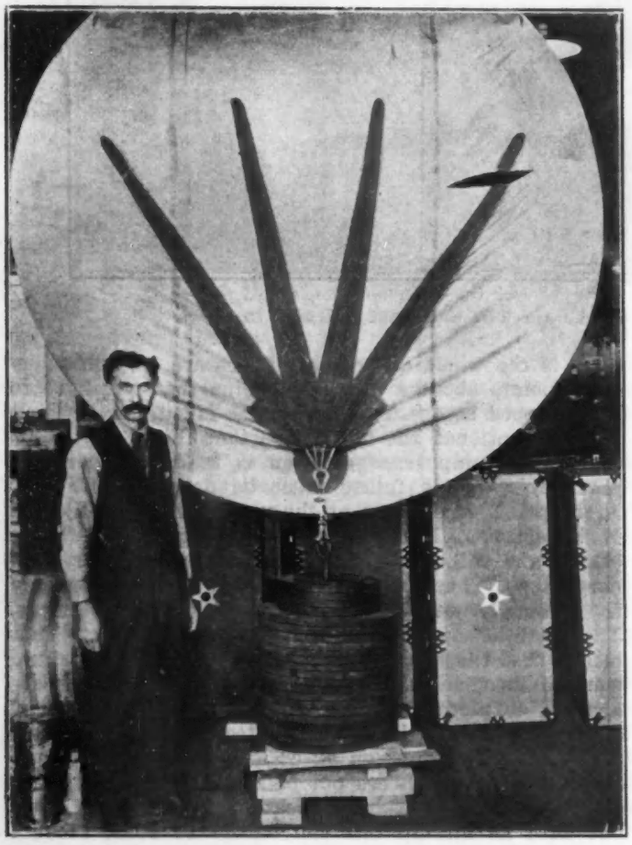
We have recently tested a new device in flight by which water can be pumped up from below to replace the weight of the fuel that is consumed. We can run until 200 lb. light and then pick up water to compensate for it. This is important in an ocean trip for it saves what is really the life of the ship. Starting out with full fuel capacity no ballast is needed at first, but if gas must be released to compensate for the fuel consumed a point is soon reached where not much reserve is left. If the engine should then fail the situation is serious, but if in the meantime water or any other disposable load has replaced the used fuel the life of the ship can be preserved. It can still free-balloon for a few days, and, of course, it has a wireless equipment that can summon help from wherever it can be reached.

QUESTION:—What would be the probable flying altitude?

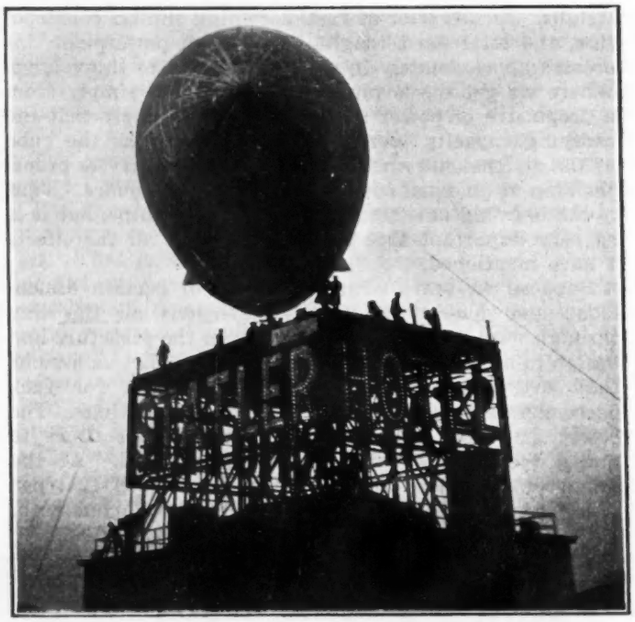
MR. UPSON:—Anywhere from 500 to 5000 ft. for ordinary passenger flights, depending upon the winds. I have mentioned before the matter of combating the weather. To be a practical success an airship must have enough speed to buck the ordinary winds which may be expected along the route and also sufficient speed to

(*Concluded on page* 375)

[2] The author flew from Akron to Cleveland in an Army airship on the afternoon of the meeting and landed on the roof of the Hotel Statler.



A SUSPENSION TEST OF A PATCH WHICH FAILED WHEN A LOAD OF 2000 LB. WAS APPLIED



ARRIVAL OF THE AUTHOR AT CLEVELAND ON THE AFTERNOON OF THE MEETING VIA AN ARMY AIRSHIP

Steam Automotive System

By LEWIS L. SCOTT[1] (*Member*)

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

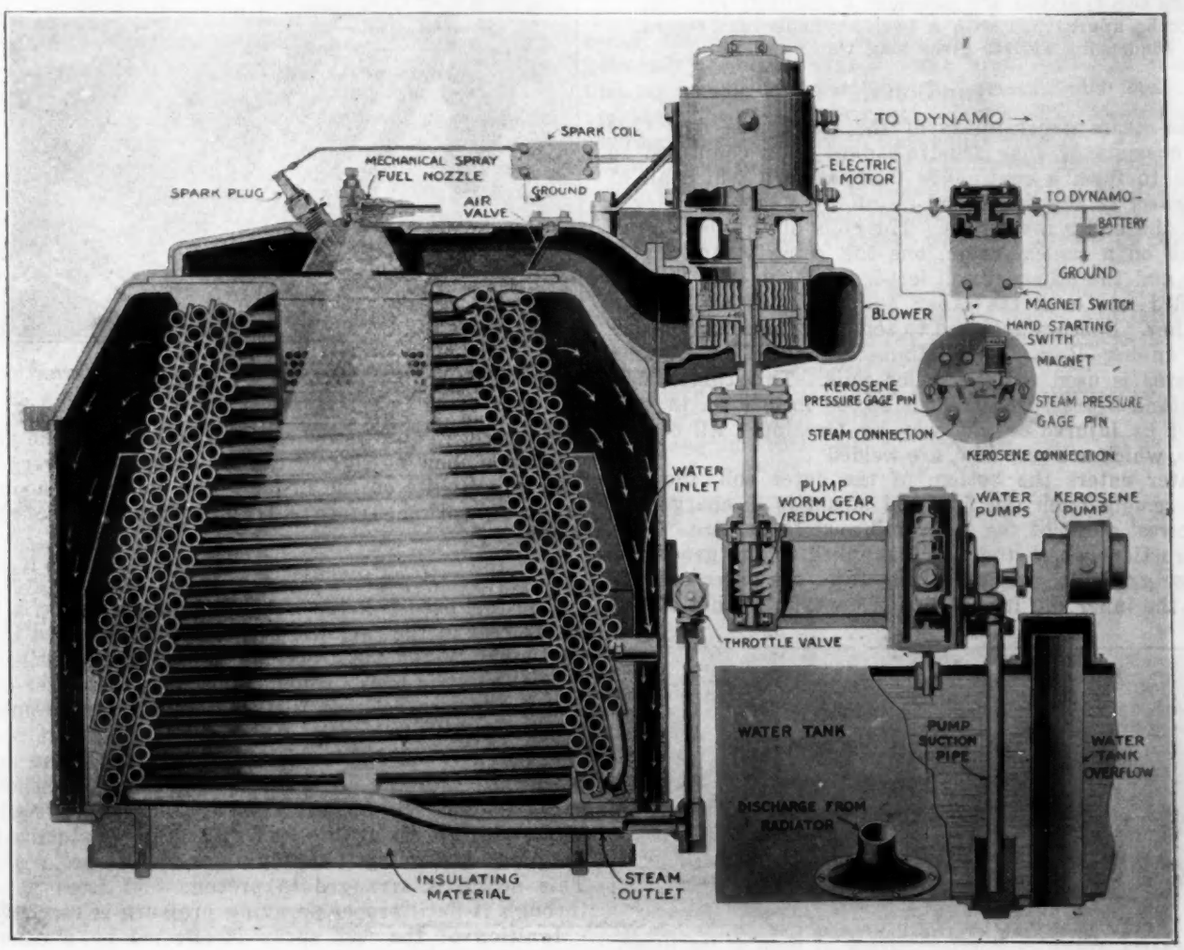
IT is generally conceded that so far as flexibility, smoothness of operation, simplicity of control, accelerating ability and high torque at low speeds are concerned the performance of the steam-propelled automobiles has never been equaled by that of the most highly developed multiple-cylinder gasoline cars. Yet when we consider the time required to raise steam, the expert attention and labor in operation, the short life of the boiler, the complicated and unreliable automatic devices, the danger from fire and explosion, the clogging of the burners, the short water mileage, etc., it is easy to see why the automobile buyer has been willing to put up with even the one-cylinder gasoline car in preference to the steam vehicle.

Ever since the day of the one-cylinder automobile, designers have been trying to build gasoline cars that could approach the performance of the steam car. The result has been the addition of one complication after another, the twelve-cylinder engine being perhaps the final effort in this direction.

The significant thing, however, is that no innovation in the gasoline car line has been able as yet to deliver steam car performance. It appeared to me after an analysis of the situation that the obvious thing to do was to remove the troublesome features of the steam car, rather than add complications to the gasoline car in the effort to duplicate the performance of the steam car. In view of these facts and of the present fuel situation, I believe that a description of the steam automotive system[2] de-

[1]Chief engineer, Standard Engineering Co., St. Louis, Mo.

[2]Mr. Newcomb's first development work on the steam automobile was carried on from 1900 to 1906. One of his early steam cars was described in the *Horseless Age*, Jan. 28, 1903. This was the foundation work around which some parts of the present systems have been developed.



THE RELATIVE POSITIONS OF THE VARIOUS PARTS OF THE SYSTEM

veloped by E. C. Newcomb and myself will prove of interest to engineers who are studying the problem of the use of steam at high pressures and temperatures, irrespective of its application to automobiles. While I will describe this system as applied to a motor car, it can be applied with equal advantage to a motor truck or tractor. This steam system has been in successful operation in an automobile for over one year. The following is a brief outline of what has been accomplished:

Steam can be raised from a cold boiler to a working pressure in about ½ min. No manual operation of any kind is required in starting, other than closing an electric switch

Only one kind of fuel is used, such as kerosene or heavier fuel. No pressure is carried in the fuel tank. The fuel is ignited in a cold state by a common spark-plug and is cleanly and completely burned. No vaporizing of fuel or pilot light is required

The boiler will not prime, is non-explosive, will not "crust-up" or scale and can be forced to any degree required in service. The car will run a mile on stored steam, after the fire is shut off. Spark-plug and boiler coil sooting troubles have been eliminated

All complicated automatic control devices have been eliminated. The steam-pressure gage is arranged to control the pressure and temperature of the steam automatically. All stuffing-boxes have been eliminated from the water-pumps and engine. The water-pump is noiseless in its operation. No cushion is required

The engine is of a highly efficient semi-uniflow type, having a steam rate of about 12 lb. per hp.-hr. It has only two cylinders and possesses a flexibility that cannot be approached with a twelve-cylinder gas engine. A condensing system gives long water mileage

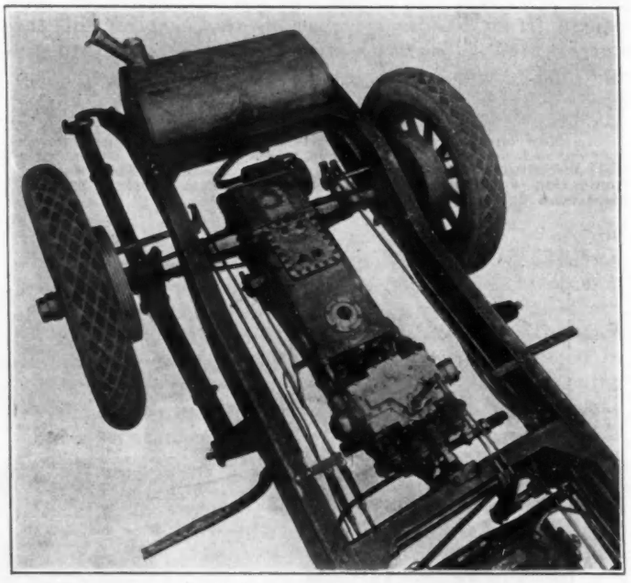
The Boiler

The steam generator is of the continuous flow type and consists of four frustro-conical coils connected in series to form a continuous tube through which all of the water to the boiler and all of the steam discharged from the boiler must pass. The coils of this boiler are wound on a conical drum, one coil being wound right-hand and the adjacent coil left-hand. The coils are assembled one over the other and the ends are welded together. Spacers are used to separate the coils. Nickel steel tubing ½-in. inside diameter and ¾-in. outside diameter is used for the boiler coils. This tubing will withstand a pressure of about 35,000 lb. per sq. in. and cannot be injured in any way by freezing. All of the joints, which are very few, are welded.

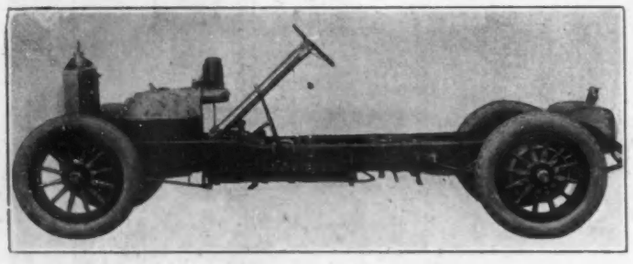
Water enters the bottom of the outer coil, the coil most remote from the fire, and steam is discharged at the lowest point of the inner coil next to the fire. This construction causes the liquid supplied to the generator to flow gradually and uniformly from the outer coil toward the inner coil in a direction opposite to that of the flow of the products of combustion, and the liquid is gradually and uniformly heated and prevented from flowing by gravity to the inner coil or coils, as it would if the coils were arranged one above another.

The inner coil surrounds the combustion chamber, and the products of combustion as they pass between the coils are brought into contact with successively cooler heat-absorbing surfaces. Therefore, the available heat is nearly all absorbed. The stack temperature runs from 250 to 350 deg. fahr. It is not necessary to insulate the outer shell that covers the boiler coils. This shell can be removed in a few minutes, so that the coils are very accessible.

Circulation of water through the boiler is dependent upon action of the water-pump. The velocity of the steam through the boiler is approximately 450 ft. per sec. Owing to this high steam velocity and to the use of deflocculated graphite mixed with kerosene for lubricating the engine cylinders, scale and deposit troubles have been eliminated. Tubes sawed out of a boiler after one year's operation show no sign of deposit except for a very thin film of graphite on the inside. The boiler has about 72 sq. ft. of heating surface and can produce 500 lb. of steam per hr.



The Engine of the Passenger Car Is Mounted Partly on the Rear Axle and Partly on the Frame

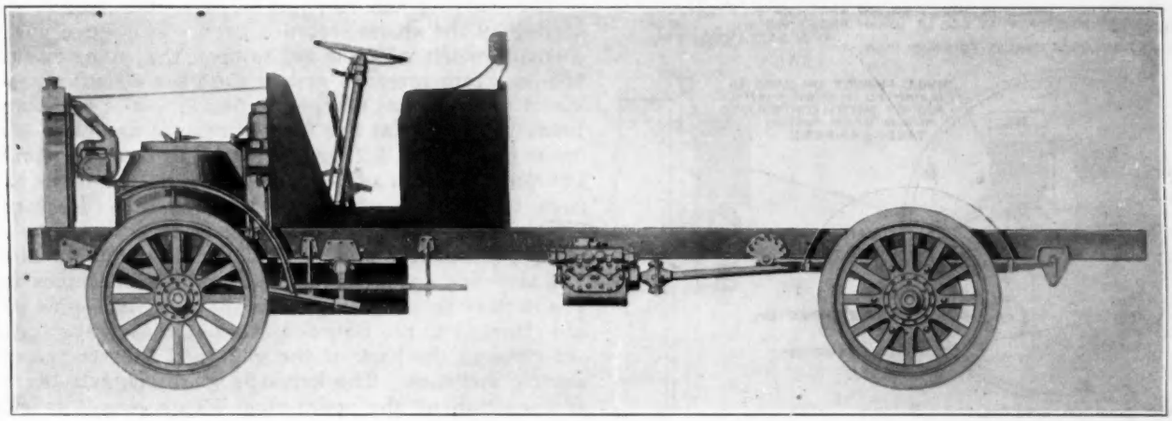


Side View of the Passenger Car
The Dynamo, Which Is Mounted Directly in Back of the Boiler, Determines the Height of the Dash

Combustion System

The fuel used is kerosene or fuel oil, carried in a tank at the rear of the car. No pressure is maintained in the fuel tank. When the fire is on, the fuel-pump, driven by a small electric motor which also drives the water-pump and air blower delivers fuel to a mechanical atomizing nozzle located at the top of the boiler, whence it is discharged at about 35-lb. pressure in a very fine spray downward into the combustion chamber. Attention is called to the fact that air from the blower has nothing to do with atomizing the fuel. The fuel is atomized by the pressure forcing it through a nozzle of special shape. This nozzle is arranged to prevent fuel from passing through it until proper spraying pressure is reached.

Ignition of the fuel spray is effected by a common spark-plug. The terminals of the spark-plug are located



A 2-Ton Truck Equipped with the Steam System

in a zone where the mixture is very rich. Air to support combustion is supplied by the blower. The ignition of cold kerosene by a spark and the efficient and complete burning of the fuel depend upon the size of the kerosene particles, their velocity, the quantity of heat in the spark and its location, the arrangement for supplying air to complete the combustion and the size, shape and arrangement of the combustion chamber.

If a particle of fuel of a given size moves at a certain velocity through an electric spark, it must absorb enough heat to bring the temperature of the particle up to the flash-point or combustion will not take place. Hence the fuel must be broken into very fine particles and the spark located in a zone where the mixture is rich. By so doing the spark-plug soon accumulates soot which will short-circuit it in a day's run. To overcome this trouble a short funnel is placed around the spray and the terminals of the plug, which are made extra long, are allowed to project through a hole in the funnel. An air space is between the porcelain of the plug and the funnel. This eliminates all trouble from soot deposits.

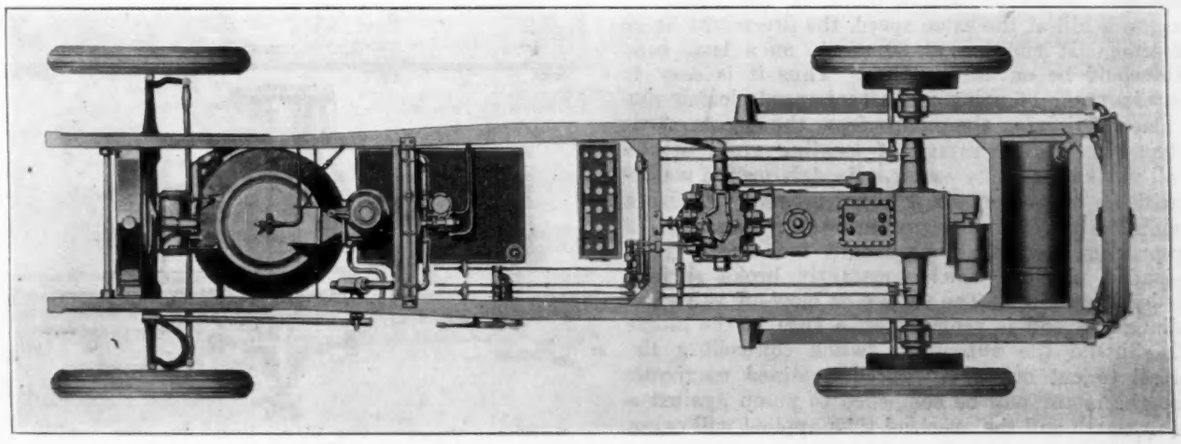
The combustion of atomized fuel is usually accompanied by a very objectionable roar, due to the varying rate of flame propagation in a mixture of gas and air of changing proportions. In a mixture of constant proportions the various parts of the flame move at different velocities and cause a similar noise. To secure a rapid reaction of the fuel mixture when ignited, a double funnel is arranged to project into the top of the combustion chamber. The funnels are made of sheet nickel about 1/32 in. thick. While the temperature at this point is not high, the funnels heat up instantly and catch and vaporize all stray particles of fuel. The use of the funnels practically eliminates the noise.

The burning of atomized fuel requires the use of a long combustion chamber. Great difficulty has been experienced by others in the past with failure of refractory linings on account of flame impingement. It is necessary that combustion be complete before the fire touches the boiler tubes or deposits of soot will form. With the combustion chamber as shown in the sectional view of the boiler, the fire cannot play on any coil and the heat is gradually absorbed over a large area, with the result that no trouble is experienced in burning boiler coils or breaking down the refractory lining. The combustion chamber is surrounded by the boiler coils.

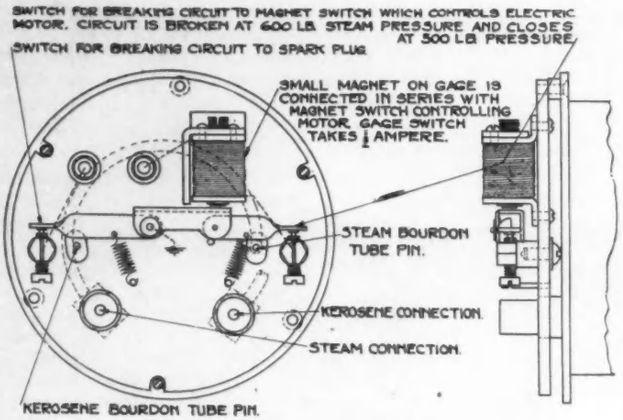
The air-valve or shutter in the blower discharge line opens when the blower is running and closes by gravity when the blower stops. It prevents back-flow of heat from the combustion chamber when the blower is not in operation.

Under normal operation the temperature of the inner boiler coil never rises above 800 deg. fahr., and the coil is therefore not subject to the oxidation which would result at higher temperatures.

In some boilers we have coated the inner coil with aluminum and then purposely subjected it to temperatures ranging from 1400 to 1800 deg. fahr. It is sur-



View Looking Down on a Steam Passenger Car


SWITCH FOR BREAKING CIRCUIT TO MAGNET SWITCH WHICH CONTROLS ELECTRIC MOTOR. CIRCUIT IS BROKEN AT 600 LB. STEAM PRESSURE AND CLOSES AT 500 LB PRESSURE.
SWITCH FOR BREAKING CIRCUIT TO SPARK PLUG
SMALL MAGNET ON GAGE IS CONNECTED IN SERIES WITH MAGNET SWITCH CONTROLLING MOTOR. GAGE SWITCH TAKES ½ AMPERE.
STEAM BOURDON TUBE PIN.
KEROSENE CONNECTION.
STEAM CONNECTION.
KEROSENE BOURDON TUBE PIN.

DUPLEX STEAM & KEROSENE GAGE
SHOWING ELECTRIC SWITCHES OPERATED FROM BOURDON TUBES OF GAGES

prising how this coating prevents oxidation at high temperatures.

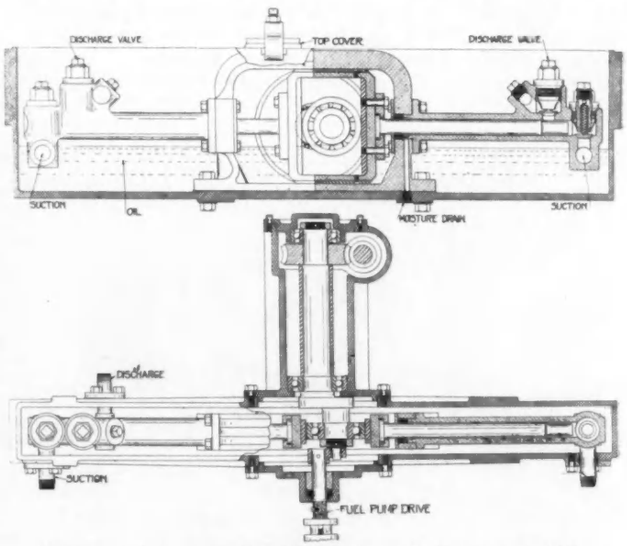
Combustion Control System

Great difficulty has heretofore been experienced in maintaining an even pressure and temperature in the automotive use of the continuous-flow type of boiler. Pressures and temperatures either too high or too low lead to burning of boiler tubes, burning out of packing and to irregular running of the car. Control systems of the past included numerous by-pass, steam automatic and low-water automatic valves, flow meter, etc., all of which were delicate, unreliable and sluggish in action. The control we have developed consists of a steam-pressure gage which operates an electric switch that in turn controls the operation of a small electric motor. As the water and fuel-pumps are driven by the same electric motor, these liquids are pumped in unison and in a definite quantitative relation. For this reason superheated steam is delivered at a temperature and pressure ratio which is substantially unvarying. As the fuel and water-pumps are put into action almost instantly, they adjust themselves with great precision to meet situations in which the demand for power varies greatly and the variations are sudden and irregular.

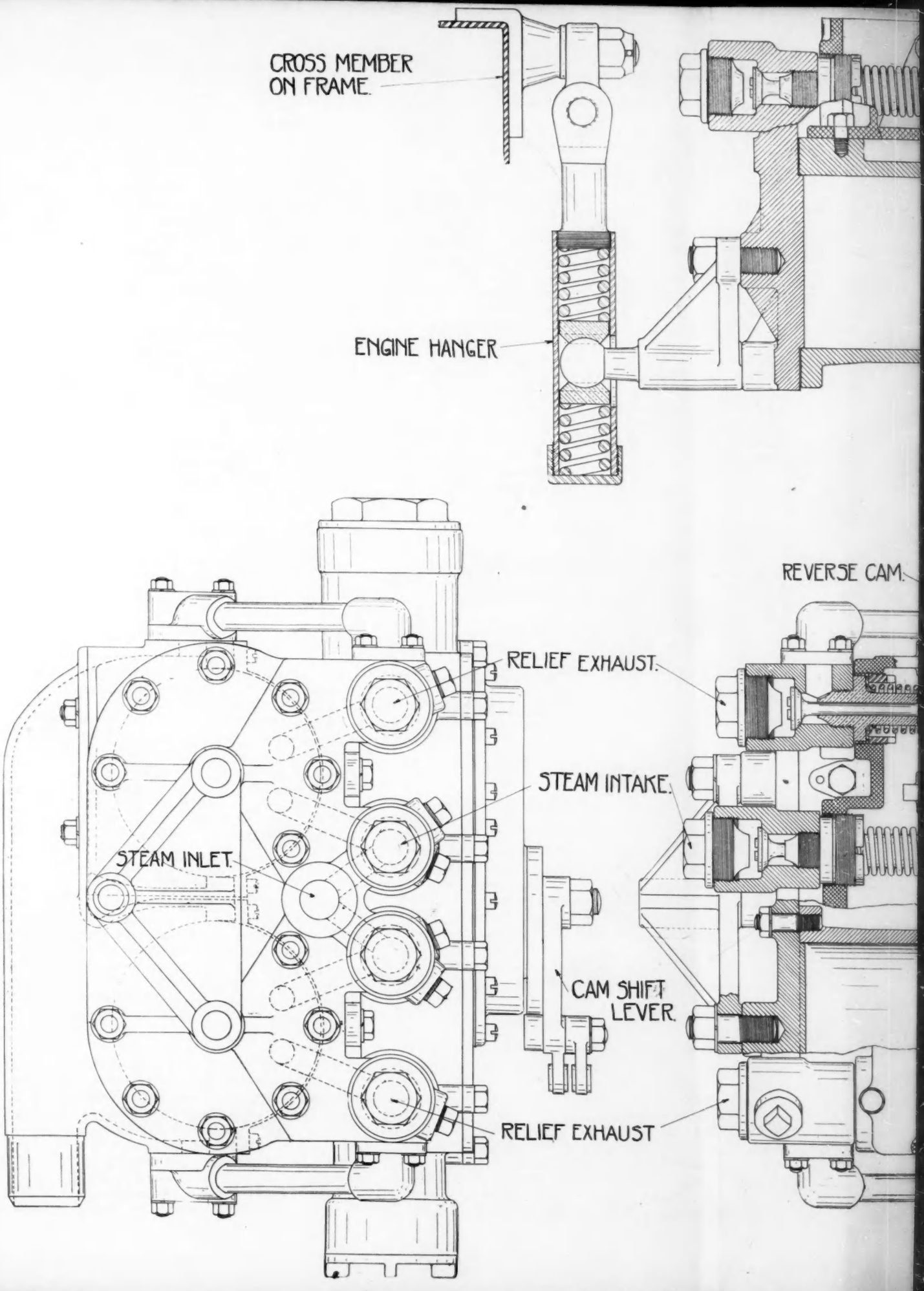
The length of time that the motor is running depends upon the demand for steam. If for example the car is running at 25 m.p.h. on a level road, the motor will run and the fire be on about one-third of the time. If running up a hill at the same speed, the fire might be on all the time. If running at 60 m.p.h. on a level road the fire would be on all the time. Thus it is easy to see the advantage of using a constant-speed electric motor in place of driving the pumps from the engine. This drive has also the advantage of locating right at the boiler all parts containing water. By driving the water-pump with an electric motor it is not necessary to use a cushion in the water line to prevent water hammer. In former practice these cushions usually took the form of spring-loaded pistons, which constantly broke springs and needed repacking. The safety or blow-off valve has been eliminated and is replaced by a fuse in the motor circuit. Should the automatic switch controlling the motor fail to cut out at the predetermined maximum pressure the motor will be compelled to pump against a greater pressure and the overload thus applied will cause the fuse to blow.

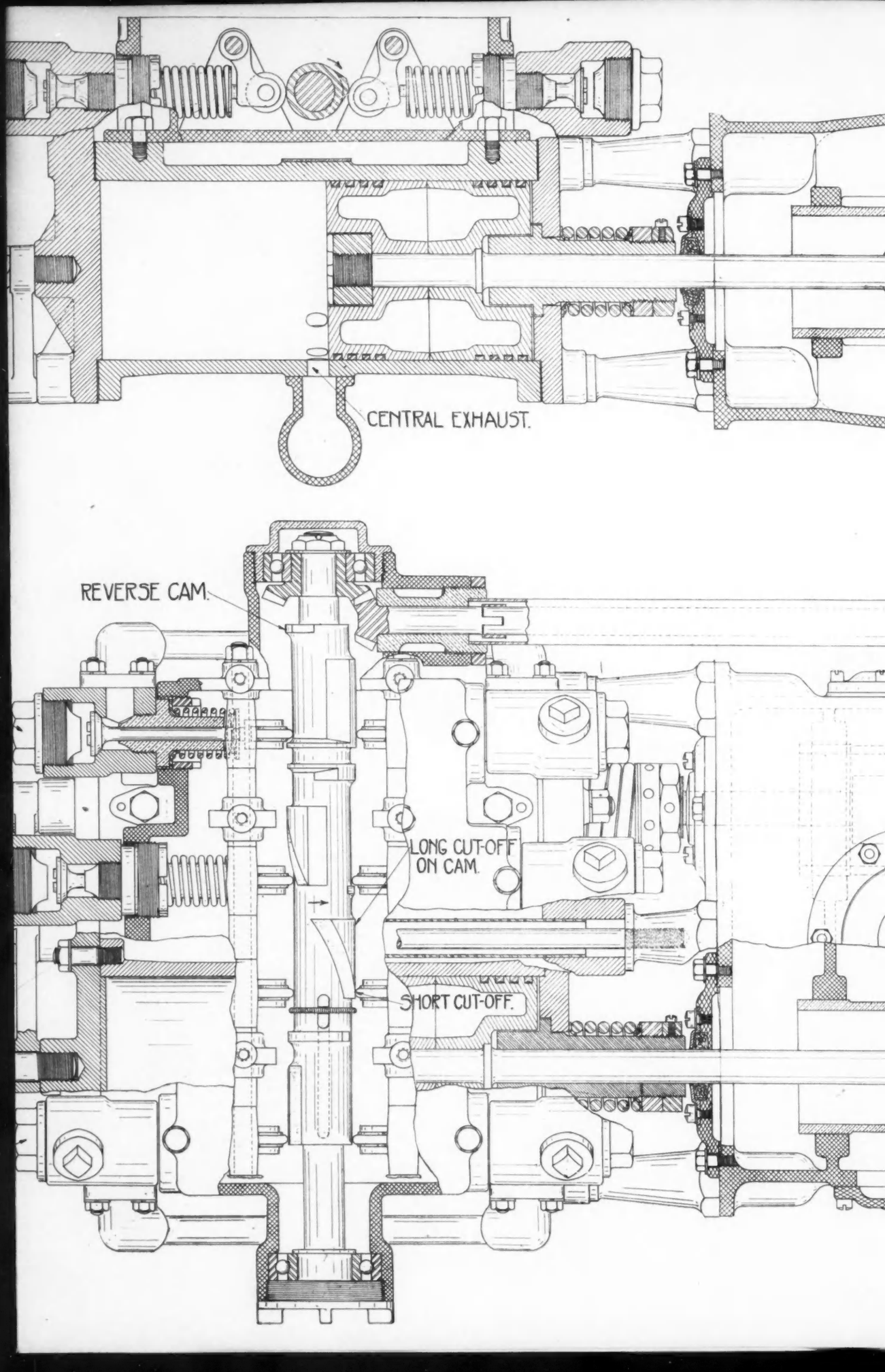
The starting and stopping of the pump motor is controlled by the steam-pressure gage. This gage operates a small switch which is set to open the motor circuit at 600-lb. steam pressure and to close the circuit when the steam pressure has dropped to 500 lb. It is necessary to break the circuit at one steam pressure and close it at a lower one. This differential action is brought about by two forces; one, a small magnet on the back of the steam gage, the other, a pin on the Bourdon tube of the gage. At the time the switch is closed the water and fuel-pumps, air blower and spark-plug all operate in unison. The kerosene and steam gages are united in duplex form. The back of this duplex gage is shown. Small pins which are attached to the Bourdon tubes of these gages project out through the back of the gage and operate the small electric switches. The kerosene gage controls the time of operation of the spark-plug. This circuit is closed from 0 to 25 lb. pressure or during the time immediately following the starting of the motor, and open above 25-lb. pressure, thus shutting off the spark after the fire is lighted. The normal pressure on the delivery side of the fuel-pump, when the motor is running, is about 35 lb. A constriction at the gage introduces a time element such that the pressure in the Bourdon tube of the gage does not build up immediately upon starting of the fuel-pump. The spark coil is connected to the motor side of the magnet switch and the spark is therefore off when the steam pressure is up to 600 lb. If for any reason the spark should fail and the combustible mixture fill the combustion chamber and be later ignited, no more harm is caused than by a muffler-explosion in a gas car.

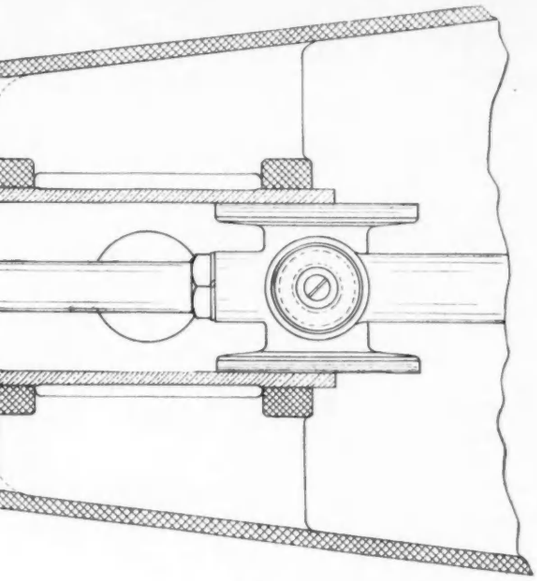
To avoid handling the motor current on the steam-gage switch, and to get a quick-acting switch in the motor circuit, a magnet switch is used to control the motor circuit. The magnet switch takes ½ amp. to operate it and this is the current carried by the gage switch. A steam temperature gage is used to indicate the temperature of the steam, which runs from 600 to 750 deg. fahr. This gage has an electric switch that closes at 800 deg. fahr. at which time the fuel will be automatically cut off from the combustion chamber. The closing of this switch causes a small magnetically-operated by-pass valve in the fuel line to open. This switch seldom comes into use in the normal working of the system, but is a safety

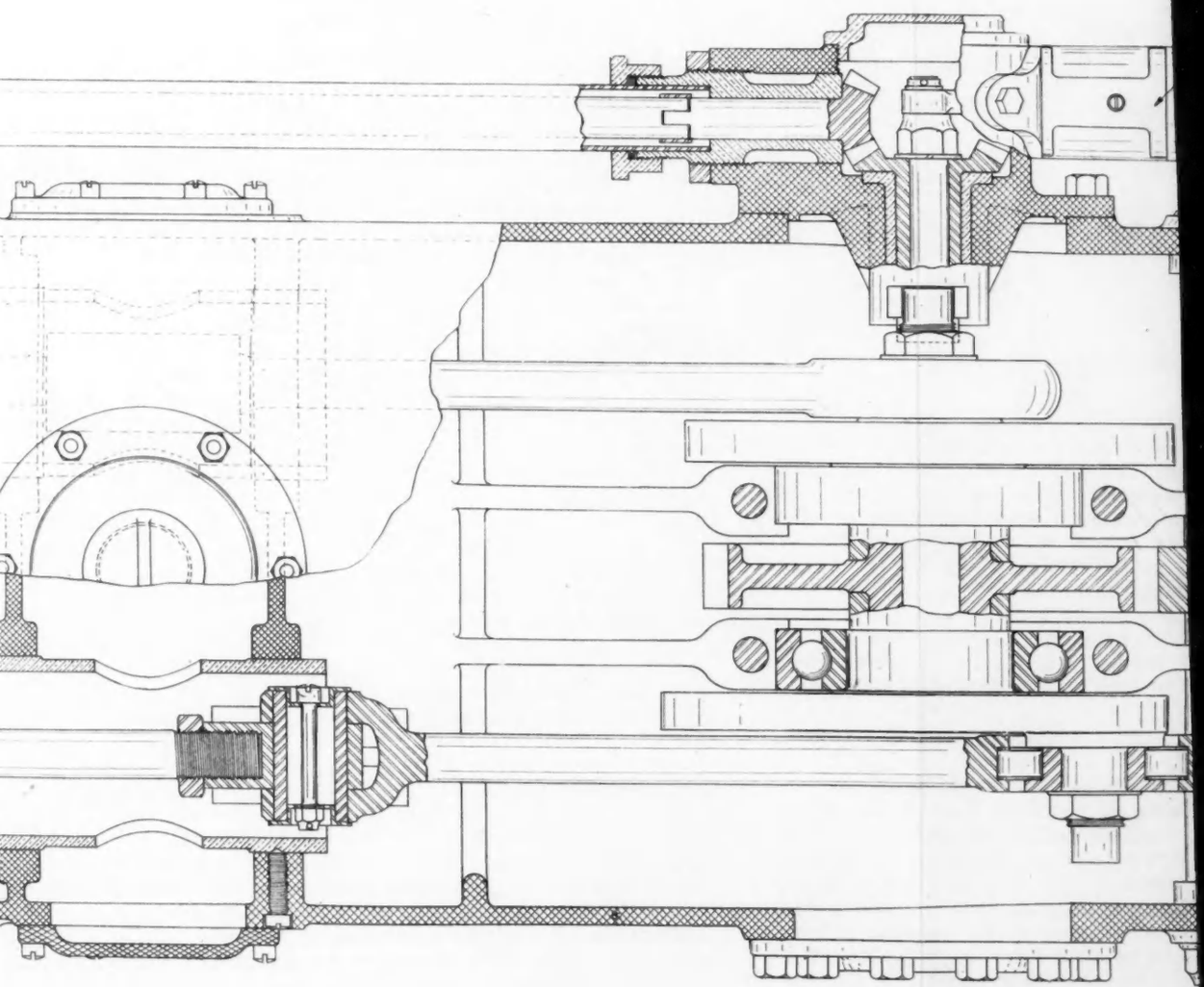


Sectional Views of the Water-Pump Showing the Worm Gear Drive


CROSS MEMBER
ON FRAME.
ENGINE HANGER
REVERSE CAM.
RELIEF EXHAUST.
STEAM INTAKE.
STEAM INLET.
CAM SHIFT
LEVER.
RELIEF EXHAUST

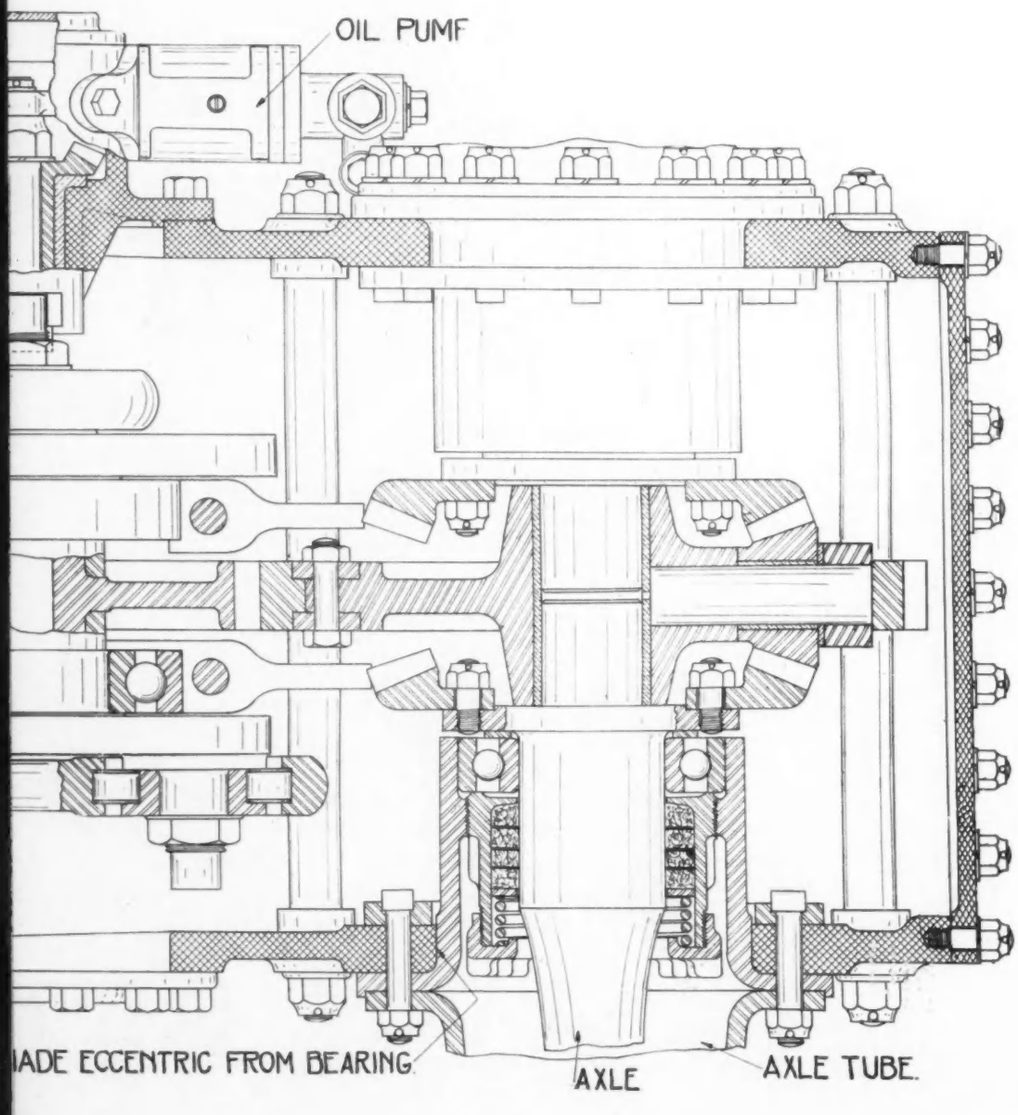

CENTRAL EXHAUST.
REVERSE CAM.
LONG CUT-OFF ON CAM.
SHORT CUT-OFF.





MADE ECCENTRIC FROM

ASSEMBLY DRAWING OF THE



Y DRAWING OF THE ENGINE

means to shut off the fire in the event that the water-tank is empty. It is also a means of correcting the fuel-water ratio if this should for any reason be deranged.

As with most gas cars, we use an electric motor, a storage battery and a generator. The motor and generator have compound windings, and the series fields of the motor and generator are connected in series. The generator furnishes all of the current to the motor direct when the engine is running; when the motor shuts off, due to steam pressure being up to 600 lb., the series field of the generator is automatically cut out, thereby reducing the output to a current suitable for charging the battery. For tractor work, where the speed of the engine is nearly constant, it is possible to eliminate the generator, motor and storage battery, but it is then necessary to have hand starting devices, a dry battery for ignition and control of small magnets which act on the suction valves of the pumps. For passenger-car applications the motor and storage battery are believed to be the most direct and simple arrangement.

One of the sources of trouble on automotive steam systems of the past was the water-pump. It was noisy, valves would not last very long, it would become air-bound when the water in the tank became too hot and required a constant adjustment of the stuffing-boxes. The valves on the water-pump used in this instance are made of special non-rusting material that has very long life. The lift of the valves is limited to 1/16 in. Because of the small lift and special design of the valve and the fact that the pump always runs at the same speed, regardless of the speed of the car, all pump noise is eliminated. As the pump has practically no clearance space it cannot become air-bound. No stuffing-box is used and the entire pump is enclosed in a case and submerged in oil. The pump plunger is made of hardened high-chromium steel; it is designed so that there can never be any side-thrust on it or on the pump cylinder and consequently there is absolute alignment at all times. By making the pump cylinder long and the bore absolutely round and straight, the wear of the plunger or the cylinder is substantially nil, there is no need of using stuffing-boxes, and a minimum amount of friction between plunger and cylinder results. The pump does not leak. These pumps have been built to work successfully against 5000-lb. pressure although the pressure in this instance never exceeds 600 lb.

The Engine

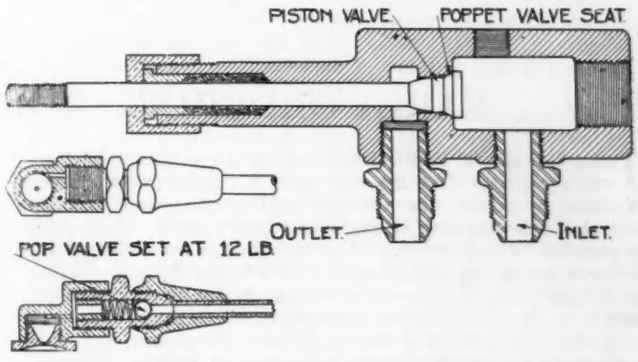
The engine is of the semi-uniflow two-cylinder double-acting poppet-valve type. The valves and piston-rods are made of non-rusting material and the former never need to be reground. The metal in the cylinder is absolutely uniform in section, so as to insure even expansion when hot. The cam box, which carries the cam and tappets for operating the valves, is thoroughly insulated from the cylinder to avoid heating of the oil carried in the cam housing. Different points of cut-off and reverse are obtained by moving the camshaft in an axial direction. The cams are of special shape to permit easy shifting and to allow an infinite number of cut-off positions. By using a short cut-off, tight valves, small clearance space, free exhaust and a uniform section of the cylinder metal, very low steam consumption is secured. The mechanical efficiency of the engine is about 95 per cent. No stuffing-boxes are used on valve-stems or piston-rods, these being unnecessary because of the use of non-rusting material, proper design and workmanship and means for maintaining perfect alignment.

The throttle-valve is made of non-rusting material Steam cannot pass the seat of the valve until the valve is far enough off its seat to give a full opening. Wire-drawing which tends to destroy the valve seat is thereby prevented. The throttle-valve is arranged to close automatically when the brake is applied.

In passenger cars the engine is mounted partly on the rear axle and partly on the frame, the greater portion of the weight being carried by the frame. The unsprung weight on the axle is small. By employing this construction the drive-shaft and universal-joints are eliminated and a smooth-riding car is obtained. In the case of truck applications the engine is mounted on the frame of the car, and a conventional rear axle used.

After steam is up the engine and car are started forward and the speed controlled by opening the throttle-valve. The cut-off position is controlled by a pedal connected so as to move the camshaft axially. The same pedal is also used to shift the camshaft to the reverse position, when backing the car. In the drawing of the engine the camshaft is shown in the shortest cut-off or most economical position.

When the engine is mounted partly on the rear axle



The Throttle Valve (Above) and the Fuel Spray Nozzle (Below)

and partly on the frame, the differential spur gear is carried in the engine case. This is an aluminum casting carefully designed to take care of all conditions met in service. There are many unique features in the differential, the principal one being the means of adjusting the differential spur gear to the engine spur gear. This adjustment is brought about by having the bearing for the axle mounted in the aluminum frame on an adjustable axis of rotation which is eccentric to the axis of the axle. This arrangement permits a very fine adjustment between the engine driving-gear and the differential gear and maintains a concentric alignment of the entire axle.

Condensing System

It is possible to obtain a water mileage of from 100 to 350 on a 25-gal. tank of water by simply running the exhaust steam from the engine into the top of a radiator which is similar to a gas car radiator and connecting the bottom with the water tank; this is without using a radiator fan. Weather and road conditions will greatly affect the water mileage. It is very desirable to get great water mileage because aside from general inconvenience the amount of foreign matter brought into the system is greatly reduced. Great water mileage will admit of the use of alcohol in the water to prevent freezing in

cold weather. One of the first things to accomplish in this matter is to have an engine that is efficient. The efficiency of the engine not only saves fuel and water but determines the size of the boiler. The exhaust steam from the engine must be properly distributed at the top of the radiator and the discharge from the radiator to the water tank must be distributed to prevent noise. It is desirable to have a radiator fan driven by the exhaust steam from the engine. If the fan is mechanically driven from the engine it will not do very much good on long hills or on heavy pulling where the car is moved slowly and the steam consumption is large. The ordinary exhaust turbine will not do for this work on account of the constantly changing load. If the turbine nozzles are set so that the turbine will run at average road speeds and the car is operated at higher speeds or in heavy pulling, the back-pressure on the exhaust line will be so high that the engine power will be materially reduced. If the nozzle area is set to keep down the back-pressure, the turbine will not run except when the engine is operating under a heavy load. We have experimented with an exhaust actuated turbine which is provided with automatic means for increasing the nozzle area as the volume of steam increases, thereby keeping the steam velocity approximately constant irrespective of variation in steam volume.

It is probably not generally known that a properly designed automotive steam plant using steam at 600-lb. pressure and 700 deg. fahr. temperature has a total efficiency at the rear wheels of about 15 per cent or more. While this is slightly below the full-load efficiency of the average gasoline car, it must be kept in mind that the efficiency of the internal-combustion engine is at its maximum only at full engine power. This is not true with the steam engine, in which the efficiency increases as the load decreases. Most automobile engines run at about one-fourth load the greater part of the time, and under this condition the efficiency of the steam engine is much above that of the gas engine plant. We have obtained from 12 to 15 miles from a gallon of kerosene under average road conditions with seven passengers in a car weighing without load 4200 lb.

In a recent test this car ran 1325 miles on a 25-gal. tank of water, or about 53 miles per gal. of water. The car was driven at speeds of 25 to 35 m.p.h. over average St. Louis County, Mo., roads, and averaged slightly over 12 miles per gal. of kerosene. The temperature of water in the water tank at the end of a long run is 130 deg.

EARLY ORDERING OF ROAD MATERIALS URGED

THE Bureau of Public Roads of the Department of Agriculture urges that the contracts for as great a mileage of roads as possible be awarded in December and January, and that the shipping of materials begin earlier than usual to overcome the deficiency of open-top cars for transporting material when the season opens. While the Bureau realizes that the placing of material in storage which may result from such a course involves some expense, it will be small compared with the loss that will result if contractors are not in a position to go ahead with work because of lack of material. It seems probable that in the case of contracts which are not awarded during the winter months there will be little opportunity for supplying materials that require rail transportation. This statement is based on the experience of last spring when the transportation of road material was delayed on account of the war. The expenditures for hard surface highways in 1919 will, it is estimated, set a new record with a total of $138,000,000, while the sum available for 1920 is placed at $633,000,000. Included in this sum are unexpended balances from 1919 contracts as well as taxes and the proceeds of recent bond issues which will become available early in the year 1920.

DECLINE OF THE HORSE IN NEW YORK CITY

IF the results of the investigation recently conducted in New York City by the United States Department of Agriculture are typical of the other cities of the country, the horse will soon become extinct in the urban districts of the United States. The census enumerators of 1910 found 128,224 horses in New York City, while the stable statistics of the sanitary bureau of the municipal Board of Health accounted for 108,036 horses in 1917 and 75,740 in 1919. Assuming that the enumerations of the two agencies are fairly comparable, it appears that 16 per cent of the number of horses of 1910 had been lost by 1917 and 41 per cent by 1919. Over 25 per cent was lost in the last 2 years and over 16 per cent in the preceding 7 years. In the older and more congested business sections of the city about 38 per cent of the horses have been displaced, while in the outlying territory the displacement averages about 57 per cent. The movement has been less intensive in the last 2 years than from 1910 to 1917.

Progress in Automotive Fuel Matters

FURTHER progress has been made regarding the automotive fuel matters of which an extensive account was given in the September JOURNAL and which were briefly noticed in the October issue.

The Automotive Fuel Committee, composed of representatives of the Society of Automotive Engineers, Manufacturers' Aircraft Association, Motor and Accessory Manufacturers' Association, National Automobile Chamber of Commerce, National Gas Engine Association, National Association of Engine and Boat Manufacturers, National Implement and Vehicle Association, Bureau of Standards, Bureau of Mines and the Smithsonian Institution, met in Chicago on Sept. 29. Those present at the meeting were Henry M. Crane, M. L. Heminway, C. R. Short (in place of K. W. Zimmerschied), H. C. Dickinson, W. S. James, W. A. Jacobs (in place of E. W. Dean), Harry L. Horning and Herbert Chase. P. S. Tice, F. C. Mock and R. J. Broege of the Society's Committee on the Utilization of Present Fuels attended the meeting by invitation. Mr. Horning was elected chairman of the committee and Mr. Chase secretary. The work done to date in relation to fuel and fuel research matters, by or in cooperation with the Society, was outlined. It was stated that the particular purpose of the meeting was to act upon a resolution adopted at the meeting of the Conference Committee of the Automotive and Fuel Industries, a report of which appeared in the September JOURNAL. This resolution provided that a definite list of the problems of the automotive industry relating to engine fuel and its use should be furnished to the oil industry. The meeting was largely devoted to a discussion of the formulation of such a list. It was agreed that this list should be prepared in the form of a report for further consideration and revision by the committee. The report as finally revised and approved by the committee is summarized below.

REPORT OF THE AUTOMOTIVE FUEL COMMITTEE

The effects of failure to overcome the difficulty of vaporizing fuels which have a wide range of boiling points or a steep distillation curve include (*a*) incomplete combustion with a consequent waste of fuel, (*b*) dilution of crankcase oil with unburned fuel which passes the pistons and frequently results in a failure of the lubricating system, (*c*) difficulty in securing good distribution and (*d*) less convenience in the use of cars.

The first is evidenced not only in a higher consumption of fuel than is necessary, but in the fact that an analysis of exhaust gases reveals both unburned hydrocarbons and considerable quantities of carbon monoxide as well as some free carbon. The average carbureter is set too give too rich a mixture, for the reason that the actual performance and handling of the engine are thereby improved. This in effect means that the more volatile portions of the fuel are burned, while the less volatile are only partly burned or do not enter into the combustion at all. The tendency to utilize an over-rich mixture is much less in the case of fuel having a 300 deg. fahr. end-point.

An important difficulty resulting from the incomplete combustion is the carbon deposit which forms in the combustion chamber. This deposit accentuates the tendency to "knock" and causes

(1) Deterioration of valves and seats
(2) Deterioration of lubrication
(3) Deterioration of radiating capacity of combustion-chamber wall
(4) Fouling of spark-plugs with attendant irregularities in ignition and waste of fuel

The fuel which mixes with the lubricant is largely composed of heavy ends that are not fully vaporized even in the heated combustion chamber. The dilution not only results in less effective, or a total failure of, lubrication but necessitates more frequent changes of the lubricant and thus causes a secondary and unnecessary waste.

The difficulty of securing good distribution increases in proportion to the decrease in volatility of the fuel, it being very difficult to handle mixtures of air and liquid fuel without separation of the two, with consequent irregularity in the mixture supplied to various cylinders. With some cylinders receiving a mixture too rich and others a mixture of proper proportion there is, of course, a waste of fuel. Distribution difficulties are apt to be especially pronounced on older cars designed for the use of more volatile fuels than are generally marketed today and consequently without proper manifold heating.

In cold weather it is not uncommon for persons who drive their own cars to lay them up because of increasing difficulties which are encountered in starting, failure of lubrication and irregular operation due to less volatile fuel. The most important of these difficulties are (*a*) difficulty of starting, especially in cold weather when the temperatures of engine cylinders are too low to vaporize any but the most volatile portion of the fuel, (*b*) decrease in accelerating ability and (*c*) decrease in economical engine temperature range.

During the starting period the heavier portions of the fuel either pass through the cylinder without being burned at all, or are deposited on the cylinder walls and thence run down into the crankcase, wash away the lubricant and dilute the lubricant in the crankcase. The difficulty in starting makes it necessary to crank the engine for a considerable period, and this results in a heavy drain upon the battery in the case of cars equipped with electric starters, which must be recharged with a consequent waste of fuel.

The decrease in accelerating ability is attributable to irregularities in mixture proportion which are accentuated by the incomplete vaporization of fuel in the inlet manifold, and in particular difficulty in vaporizing the less volatile portion of the fuel.

In every case an engine must reach a certain minimum temperature before it operates smoothly and most economically. There is also a high temperature above which engine operation becomes unsatisfactory. The less volatile the fuel, the higher is the minimum temperature below which satisfactory operation is not obtained. This means that with heavier fuels a longer time is required in warming up, during which the quantity of fuel used is necessarily greater than would be the case if the engine reached an efficient operating temperature in a shorter period. The narrower the temperature range, the more complicated are the devices necessary to secure satisfactory operation and the more intelligent the operator required.

The most prominent of the difficulties due to fuel characteristics which yield undesirable combustion phenomena is the development of high-pressure waves resulting in so-called "knock" with the consequent tendency to deterioration in the engine.

One result of the knock phenomenon is the tendency of drivers to adjust the carbureter so as to give an over-rich mixture and to use a retarded spark, both of which tend to reduce or eliminate the knock, but also result in a considerable waste in fuel. To avoid the tendency to knock with most heavier fuels, it has become very common practice to decrease the compression ratios of engines. This has resulted in a decrease in the efficiency of fuel utilization, as well as in lower horsepower and a tendency to a further increase in the carbon deposits.

The following observations have been made individually by members of the committee in connection with the report:

DR. JOSEPH E. POGUE:—The difficulties now being encountered with engine fuel are due to a lack of coordination between the automotive and the oil industries, which is responsible for a 10 per cent waste or a loss or nearly 10,000,000 bbl. per year. This is not a creditable showing. Either the oil refiners in concert should come back to standards of higher volatility such as will minimize this waste, or else the automotive manufacturers, through the development of accessories for cars in use or in new construction, should adapt automotive apparatus to burn efficiently the less volatile fuel now being turned out. This question should be settled one way or the other at the earliest possible moment, and the decision should be based upon broad economic principles. A decision based upon expediency, differential advantage or a too restricted point of view will inevitably retard the development of automotive transportation and will react to the disadvantage of both industries.

H. L. HORNING:—In the better understanding of the knock and its control and elimination lies the most promising field for the cooperative effort of the automotive and petroleum industries. It is conservative to expect an increase in power output per pound of fuel and per cubic inch of engine displacement of 25 per cent with the knock controlled. No one factor limits the satisfaction of the public in driving so much as this one of the knock. While hard starting, carbon in the cylinder, dilution of the crankcase oil and extravagance in fuel remind the user periodically of the decreasing quality of fuel, the knock is with him always, ever a limiting factor in acceleration and in power output from a given size of engine, always limiting him at a slight rise in level, everlastingly menacing smooth operation in hot weather and always the most disagreeable experience in the operation of modern automotive apparatus. While there is a question as to how long engines can withstand the destructive action of the knock, there is indisputable evidence that engine life is reduced materially by it. The average piece of automotive apparatus is subject to a depreciation due to the knock which is an important economic factor.

This report has been forwarded to members of the Conference Committee of the Automotive and Petroleum Industries which, it will be recalled, includes five representatives appointed by the American Petroleum Institute.

The Automotive Fuel Committee which is composed largely of technical men is endeavoring to bring about arrangements whereby the members of the committee can meet with technical representatives of the fuel producers and refiners to discuss the difficulties attributable to the utilization of present fuels in automotive apparatus and other problems of mutual interest in the hope of bringing about a solution of some of them. It is appreciated that much research work will be required before many of the problems are solved, and it is expected that steps will shortly be taken to formulate and carry through a research program for the purpose of securing much needed data. Considerable work along this line is already in progress or about to be begun at the Bureau of Standards in Washington. Much work having a bearing upon the situation has, of course, been in progress at the Bureau for some months and reports upon certain phases of this work will form the basis of some of the papers to be presented at the Annual Meeting of the Society. Members of the Society and others interested are requested to report to the Society upon any research work that they may have done or know about, which may well be considered in seeking the solution of difficulties covered by the first report of the Automotive Fuel Committee.

Following the meeting of the Automotive Fuel Committee on Sept. 29, a meeting of the Society's Committee on the Utilization of Present Fuels was held on the same day. The purpose of this committee is to formulate recommendations which, it is hoped, will bring about a more efficient utilization of present fuels for automotive apparatus now in use or shortly to be constructed. A report on this subject is now in preparation. The committee hopes to persuade manufacturers of automotive apparatus to give greater consideration to construction details, which will make possible a more efficient use of fuel than is generally secured at present. It is believed that adequate consideration has not been given to this matter and that the consequent waste of fuel may hasten the stringency of the fuel supply which has for many years been foreseen.

GASOLINE SPECIFICATIONS

It will be recalled that during the war there was created by presidential order a Government Committee on the Standardization of Specifications for Petroleum Products, and that this committee adopted a specification for engine gasoline which was issued by the Fuel Administration in October, 1918. This specification was printed in THE JOURNAL for December, 1918, page 406, and provided for an initial boiling point not higher than 140 deg. fahr., that 20 per cent of the sample distill below 221 deg. fahr., 45 per cent distill below 275 deg. fahr., and 90 per cent distill below 365 deg. fahr., the end-point to be not higher than 428 deg. fahr. This specification was drafted to cover federal purchases of gasoline for both domestic and military uses and represented a grade equivalent to a large portion of the engine gasoline marketed in the calendar years 1917 and 1918. It has since been included in several state and municipal legislative acts regulating the sale and quality of gasoline.

The specification has, however, been criticised by producers as being too rigid for present refining and marketing practice, some claiming that if all gasoline produced conformed to this specification the supply of fuel would be materially reduced. While it was not originally the intention of the committee that the specifications be very generally used, experience has proved that the specifications were likely to be prescribed as standard in laws enacted by various legislative bodies to govern the sale of gasoline to the public. The committee, therefore, deemed it advisable to propose only such specifications as would be reasonably satisfactory in use, and which would not too greatly restrict the total available supply and thus be detrimental to the public good if adopted universally. It was, of course, necessary to state the problem of determining what constituted a practical specification for engine gasoline, having due regard to the total available supply and to satisfactory use in the engine. It was recognized that the system of devising specifications must necessarily be flexible and permit revision from time to time as warranted by the changing conditions of supply and demand. The varying conditions of use, such as engine

construction, lubrication, climatic changes and personal preferences of operators, were recognized, but it was considered that specifications might well be adopted covering what experience had proved to be generally satisfactory under existing circumstances. The Bureau of Mines was therefore requested to make a survey of gasoline marketed throughout the entire country. Over 800 samples of gasoline covering practically all types produced and sold in the country were collected from every state in the Union. These included the products of all refiners of sufficient size to be of importance in the aggregate supply. The data collected in this survey are believed to be the most comprehensive now available.

The figures obtained through laboratory analysis of these samples were studied to ascertain what proportion met the specifications given above and it was found that only 26.9 per cent of the total met the entire specifications, although 81.7 per cent met the specifications for initial boiling point, 89 per cent met the specifications for the 20 per cent and 45 per cent points on the distillation curve, while only 37.2 per cent complied with the specification for the 90 per cent point and 50 per cent met the specification for the dry point.

As a result of the Bureau of Mines' investigation it was found that if the specifications were changed to permit an end-point of 437 deg. fahr., a 90 per cent point of 374 deg. fahr. and a 50 per cent point of 284 deg. fahr., the specification would represent present refinery practice much more nearly than does the original specification. If all the both more and less volatile gasoline produced were brought to this standard there would be a net gain of approximately 1 per cent in production. However, the present specification is producing enough gasoline for the current needs of the United States, although the theoretical loss, if this specification were adopted and rigidly enforced, would be approximately 5 per cent. Consequently, with the change in specifications mentioned, if the same ratio of theoretical refinery practice is continued, the gain in production would be about 6 per cent. The current production of gasoline appears to be sufficient at present. If allowances be made for the probable increase in production of high-grade crude oil in the Texas field, for increased importation from Mexico and an increase in cracked gasoline, the Bureau of Mines estimates that the adoption of the new specifications will make it unnecessary to change the specifications for at least two and possibly three years. It is thought that the proposed change from the present specifications will be more in the nature of a readjustment than a radical change. According to the Bureau of Mines, the present specifications do not conform to good refinery practice in that there is too great a difference between the 90 per cent point and the dry point. Also, both of these points are a little too low compared with other points in the specifications. Raising the 90 per cent point and the end-point as suggested, would remedy both these faults and balances the specifications.

In the report of the Bureau of Mines some consideration was given to the possibility of two specifications that would allow conservation of the higher grade material for military use and a lower grade than that in the proposed revision which would permit a large increase in the production of gasoline; but since the adoption of the specifications mentioned is not likely to cause any restriction of output for some time to come, and since two specifications would add confusion to the market, the Bureau favored the adoption of a single-specification plan. The Bureau's report lays emphasis on the fact that there is at present great lack of uniformity as regards quality in refining and marketing practice. This is evident from many of the figures presented. For instance, only 46 per cent of the samples tested pass the proposed specification at all points, and yet if this specification is adopted and rigidly enforced and all the engine gasoline distilled in the United States blended into a uniform product it would be well under all the limits. This shows that 46 per cent of the samples passed are sufficiently volatile to more than balance the 54 per cent that are less volatile, and a detailed study of the individual samples confirms this. The report of the Bureau concludes that this situation should be corrected, and states: "If the gasolines of the United States are made more nearly uniform, the customer can get greater economy in actual use and thus tend to conserve the available supply, and the use of one specification more rigidly enforced would be one method of accomplishing this result."

The Committee on Standardization of Petroleum Specifications after due consideration and discussion of the report of the Bureau of Mines adopted specifications embodying the changes recommended. The specification now reads as follows:

Revised Specifications for Gasoline

Quality

Gasoline to be high grade, refined and free from water and all impurities and shall have a vapor tension not greater than 10 lb. per sq. in. at 100 deg. fahr. temperature, the same to be determined in accordance with the current Rules and Regulations for the Transportation of Explosives and Other Dangerous Articles by Freight, as issued by the Interstate Commerce Commission.

Inspection

Before acceptance the gasoline will be inspected. Samples of each lot will be taken at random. These samples immediately after drawing will be retained in a clean, absolutely tight closed vessel and a sample for test taken from the mixture in this vessel directly into the test vessel.

Specifications

(1) The boiling point must not be higher than 60 deg. cent. (140 deg. fahr.)
(2) 20 per cent of the sample must distill below 105 deg. cent. (221 deg. fahr.)
(3) 50 per cent must distill below 140 deg. cent. (284 deg. fahr.)
(4) 90 per cent must distill below 190 deg. cent. (374 deg. fahr.)
(5) The end or dry point of distillation must not be higher than 225 deg. cent. (437 deg. fahr.)
(6) Not less than 95 per cent of the liquid will be recovered in the receiver from the distillation.

Test

100 c.c. will be taken as a test sample. The apparatus and method of conducting the distillation test shall be that adopted by sub-committee XI of Committee D-1 of the American Society for Testing Materials,[1] with the following modifications: (a) the temperature shall be read against fixed percentage points, and (b) the thermometer shall be as hereinafter described.

[1] American Society for Testing Materials, Yearbook for 1915, p. 568; or part 1. Committee Reports, 1916, vol. 16, p. 518. See also Bureau of Mines Technical Papers, Nos. 166 and 214.

Flask

The flask used shall be the standard 100-c.c. Engler flask, described in the various textbooks on petroleum. Its dimensions are as given in the accompanying table.

Dimensions	Cm.	In.
Outside diameter of bulb	6.5	2.56
Outside diameter of neck	1.6	0.63
Length of neck	15.0	5.91
Length of vapor tube	10.0	3.94
Outside diameter of vapor tube	0.6	0.24

The position of vapor tube is 9 cm. (3.55 in.) above the surface of the gasoline when the flask contains its charge of 100 c.c. The tube is approximately in the middle of the neck. The observance of the prescribed dimensions is considered essential to the attainment of uniformity in results.

The flask shall be supported on a ring of asbestos having a circular opening 1¼ in. in diameter; this means that only this limited portion of the flask is to be heated. The use of wire gauze is forbidden.

Condenser

The condenser shall consist of a thin-walled tube of metal, such as brass or copper, ½ in. in internal diameter and 22 in. long. It shall be set at an angle of 75 deg. from the perpendicular and shall be surrounded with a cooling jacket of the trough type. The lower end of the condenser shall be cut off at an acute angle and shall be curved down for a length of 3 in. The condenser jacket shall be 15 in. long.

Thermometer

The thermometer shall be made of selected enamel-backed tubing having a diameter between 5.5 and 7 mm. The bulb shall be of Jena normal or Corning normal glass, its diameter shall be less than that of the stem and its length between 10 and 15 mm. The total length of the thermometer shall be approximately 380 mm. The range shall cover 0 deg. cent. (32 deg. fahr.) to 270 deg. cent. (518 deg. fahr.) with the length of the graduated portion between the limits of 210 to 250 mm. The point marking a temperature of 35 deg. cent. (95 deg. fahr.) shall not be less than 100 mm. nor more than 120 mm. from the top of the bulb. For commercial use the thermometer may be graduated in the fahrenheit scale.

The scale shall be graduated for total immersion. The accuracy must be within about 0.5 deg. cent. The space above the meniscus must be filled with an inert gas, such as nitrogen, and the stem and bulb must be thoroughly aged and annealed before being graduated.

Source of Heat in Gasoline Distillation

The source of heat in distilling gasoline may be a gas burner, an alcohol lamp or an electric heater.

Procedure and Details of Manipulation

If an electric heater is used it is started first to warm it. The condenser box is filled with water containing a liberal portion of cracked ice.

The charge of gasoline is measured into the clean, dry Engler flask from a 100-c.c. graduate. The graduate is used as a receiver for distillates without any drying. This procedure eliminates errors due to incorrect scaling of graduates and also avoids the creation of an apparent distillation loss due to the impossibility of draining the gasoline entirely from the graduate.

The above mentioned graduate is placed under the lower end of the condenser tube so that the latter extends downward below the top of the graduate at least 1 in. The condenser tube should be shaped and bent so that the tip can touch the wall of the graduate on the side adjacent to the condenser box. This detail permits distillates to run down the side of the graduate and avoids disturbance of the meniscus caused by the falling of drops. The graduate is moved occasionally to permit the operator to ascertain that the speed of distillation is right, as indicated by the rate at which drops fall. The proper rate is from 4 to 5 c.c. per min., which is approximately 2 drops per sec. The top of the graduate is covered, preferably by several thicknesses of filter paper, the condenser tube passing through a snugly fitting opening. This minimizes the evaporation losses due to the circulation of air through the graduate and also excludes any water that may drip down the outside of the condenser tube on account of condensation on the ice-cooled condenser box.

A boiling stone, a bit of unglazed porcelain or other porous material, is dropped into the gasoline in the Engler flask. The thermometer is equipped with a well-fitted cork and its bulb covered with a thin film of absorbent cotton, preferably the long-fibered variety sold for surgical dressing. The quantity of cotton used shall not be less than 0.005 nor more than 0.010 g. The thermometer is fitted into the flask with the bulb just below the lower level of the side neck opening. The flask is connected with the condenser tube.

Heat must be applied so that the first drop of the gasoline falls from the end of the condenser tube in not less than 5 or more than 10 min. The initial boiling point is the temperature shown by the thermometer when the first drop falls from the end of the condenser tube into the graduate. The operator should not allow himself to be deceived as sometimes, if the condenser tube is not dried from a previous run, a drop will be obtained and it will be some time before a second one falls; in this case the first drop should be ignored. The amount of heat is then increased so that the distillation proceeds at a rate of from 4 to 5 c.c. per min. The thermometer is read as each of the selected percentage marks is reached. The maximum boiling point or dry point is determined by continuing the heating after the flask bottom has boiled dry until the column of mercury reaches a maximum and then starts to recede consistently.

The distillation loss is determined as follows: The condenser tube is allowed to drain for at least 5 min. after heat is shut off, and a final reading taken of the quantity of distillate collected in the receiving graduate. The distillation flask is removed from the condenser and thoroughly cooled as soon as it can be handled. The condenser residue is poured into a small graduate or graduated test tube and its volume measured. The sum of its volume and the volume collected in the receiving graduate, subtracted from 100 c.c., gives the figure for the distillation loss.

OBITUARIES

RALPH H. BROWN died at Cleveland, Ohio, Sept. 23, aged 33 years. He was born March 11, 1886, at Corning, Ohio, and received a general and technical education. After completing his education he was connected with a number of automobile companies and at one time was the chief engineer of the American Octurette Co., Detroit, Mich. At the time of his death Mr. Brown was the sales engineer for the Perfection Spring Plant of the Standard Parts Co., Cleveland, Ohio. He was elected to Member grade in the Society May 29, 1914.

EDWARD A. CASSIDY died at New York City on Oct. 21 after an illness of almost three months, aged 34 years. He was born at Baltimore, Md., June 13, 1885. In 1909 he was appointed treasurer and general manager of the Auto Supply Co., Baltimore, Md., and the following year came to New York as a representative of the United Manufacturers. From 1912 to 1914 he was treasurer of the Petry-Cassidy Co., Inc., Philadelphia, Pa., and on severing his connection with that firm became sales manager of the automobile accessory department of the H. W. Johns-Manville Co., New York City, and subsequently general manager of this department. In December, 1915, he organized the Edward A. Cassidy Co., New York City, and was elected president and general manager, an office which he held until the time of his death. He left a widow and one daughter. Mr. Cassidy was elected to Associate Member grade in the Society Oct. 8, 1917.

F. S. GASSAWAY died July 13 at Vineyard Haven, Mass., aged 51 years. His death was caused by heart failure following a long illness which began in the latter part of 1918. He was born at Baltimore, Md., Oct. 4, 1867, and received his education in the elementary and high schools of his birthplace. From 1891 to 1895 he was in the employ of the Electric Appliance Co., Chicago, Ill., and resigned to accept a position with the Southern Electric Co., Baltimore, Md., where he remained until 1898. From 1899 to 1900 he was with the Automatic Telephone Co., also of that city, and in 1905 entered the employ of the Helios Mfg. Co., Philadelphia, Pa. In 1909 he was appointed district manager for the Willard Storage Battery Co. and given charge of the Eastern territory. In the early part of 1917 he secured the franchise to handle Willard service in New York City, organized the firm of F. S. Gassaway, Inc., and was president of the organization until the time of his death. He was elected to Associate Member grade in the Society April 20, 1914.

W. F. HOLCOMBE died Sept. 9, of heart failure, aged 51 years. He was born at Bridgeport, Conn., Dec. 26, 1867, and received a grammar and high school education. In 1901 he organized the firm of Holcombe & Co. to manufacture small electric articles and served as vice-president and general manager until its dissolution in 1907. From that time until 1913 he was vice-president and general manager of the Auto Ignitor Co., which specialized in the manufacture of chemical lighting apparatus. From 1913 to the time of his death he was vice-president and general manager of the Lake Sales Co., New York City, and did much to develop the Wasson piston ring in a commercial way. He was elected to Associate Member grade in the Society May 14, 1917.

CHARLES F. LORD died Sept. 25 in a hospital at Chicago, Ill., aged 43 years. His death was the result of a collision between an automobile in which he was riding and a switch engine at the Deering Works of the International Harvester Co. He was born at Somerville, Mass., Oct. 31, 1875, and received part of his education in the public and high schools of his birthplace. After being graduated from the Massachusetts Institute of Technology in 1898 with the degree of bachelor of science, he was employed for a short time in the inspection department of the American Telephone & Telegraph Co., with headquarters at Philadelphia, Pa. He then returned to the Massachusetts Institute of Technology for a short time as an instructor and later became an assistant examiner in the Patent Office. In 1902 Mr. Lord entered the employ of the General Electric Co. as assistant attorney in the patent department, resigning in 1904 to take charge of the patent departments of the Bullock Electric Mfg. Co. and the Allis-Chalmers Co. He spent four years at Cincinnati and the same time at Milwaukee and for a portion of this period he was president of the former company. During his stay in Washington Mr. Lord studied at the law school of Georgetown University and was admitted to the bar in Ohio, Wisconsin and Illinois and to practice in the Federal courts and in the Supreme Court of the United States. On June 1, 1912, he was appointed general patent attorney and manager of the patent department of the International Harvester Co., a position he held at the time of his death. He was associate editor of the Encyclopedia of Engineering and wrote several text books for this publication when it was first started. Mr. Lord was a lecturer on patent law at Marquette University, Milwaukee, Wis., and during the war was a member of the War Committee of Technical Societies of Chicago. For the past two years he was chairman of the committee on patents of the National Implement and Vehicle Association. He was a fellow of the American Institute of Electrical Engineers and a member of the American Society of Mechanical Engineers, the American Patent Law Association, the Engineers' Club of Chicago and other technical organizations. Mr. Lord was elected to Member grade in the Society Jan. 31, 1918.

CHARLES N. MCFARLAND died at Jackson, Mich., Nov. 1, as a result of an operation for appendicitis, aged 50 years. He was born at Iron Mountain, Mo., Feb. 20, 1869, and received his education in the elementary schools of his birthplace. In 1884 he entered the employ of the Iron Mountain Mining Co. as a machinist and remained there for four years. The next three years he spent at the St. Louis Manual Training High School. In 1898 he entered the employ of the Burroughs Adding Machine Co. at St. Louis, Mo., as a designer and remained there until 1904 when he resigned to accept the position of superintendent of the Adder Machine Co., Wilkes-Barre, Pa. From 1908 to 1913 Mr. McFarland was superintendent of the Ellis Adding Typewriter Co., Newark, N. J., and resigned in 1913 to enter the production division of the Burroughs Adding Machine Co. In 1917 he was appointed mechanical representative in the New York office of the United Motors Corporation and at the time of his death was general manager of the Jaxon Steel Products division of the General Motors Corporation. Mr. McFarland was elected to Associate Member grade in the Society Sept. 10, 1917.

A. J. STORM died at his home in Brooklyn, N. Y., Sept. 23, aged 47 years. He was born at Detroit, Mich., on Sept. 15, 1872. From 1887 to 1903 he was employed by the Board of Water Commissioners of his birthplace, as a clerk and draftsman in the office of the superintendent of construction and later as a clerk in the accounting department. For the next two years he was a traveling salesman for the Weedsport Skirt & Waist Co., Weedsport, N. Y., and the Detroit Gas Mantle Co., Detroit, Mich. In 1906 he entered the employ of the Carnegie Steel Co. as a weigh master in the open-hearth department at the Homestead, Pa., plant, and was later transferred to the converter department at the company's Duquesne, Pa., plant. He was promoted to foreman of the pig-casting machines in that plant and was subsequently transferred to a clerkship in the general sales department at the Pittsburgh offices. At the time he severed his connection with this company in 1912 he was a salesman in its armor plate department. After leaving the Carnegie Steel Co. he entered the employ of Isaac G. Johnson & Co. as a salesman of steel castings in New York City. From 1915 to the time of his death he was salesman and Eastern representative of the Dayton Steel Foundry Co., Dayton, Ohio, with offices at New York City. Mr. Storm was elected to Associate Member grade in the Society April 12, 1918.

Mixture Requirements of Automobile Engines

By O. C. BERRY[1] (*Non-Member*)

ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND CHARTS

TO design any piece of machinery intelligently, it is necessary to know just what requirements will have to be met by the finished product. In the case of the carbureter complete and accurate information on this point is not available. This fact is pointed out in the Second Annual Report of the National Advisory Committee for Aeronautics. This report, in speaking of the object to be accomplished in carburetion, says,

> It must be admitted that there is no convincing experimental proof available from engine tests to establish definitely just what sorts of mixture give the best results in engines; whether, for example, they should be constant or variable in proportions of air to fuel, and whether also they should be dry or wet and, if the latter, how much moisture is permissible and in what form.

The art of carburetion is spoken of as just emerging from the experimental stage and previous carbureter designs as worked out on a cut and try basis. To the engineers of carbureter manufacturing companies that maintain large experimental laboratories this may seem harsh and only partly true, as these men undoubtedly have considerable information of this character upon which they base their designs. This information is not made public, however, and even the United States Government does not have access to it, as is indicated by the quotation above.

In view of the amount of money invested in the automotive industry, the essential place this industry occupies in our social structure, the great cost of the fuel used each year and the ever-increasing prospect of a serious fuel shortage, it would seem worth while to develop a comprehensive and accurate technology of carburetion and have the information available to all. Recognizing this situation, the Purdue Engineering Experiment Station has been making a study of the effect upon the performance of an engine of varying the proportions of the fuel to air in the mixture.[2]

This paper is based upon the results of these tests and has for its object a determination of the variation in the mixture requirements of an engine at different rates of flow of air through the carbureter. This is one step toward the object to be accomplished in carburetion and enables the presentation of the information desired in the form that will be the most useful to carbureter designers. A careful presentation will be made of the line of thought and the types of test data that have led to the final conclusions. The great number of tests

[1] Associate professor of gas and automotive engineering, Purdue University, Lafayette, Ind.

[2] A bulletin has just been published setting forth the results obtained up to the present time, which can be obtained by addressing Dean C. H. Benjamin, Purdue University, Lafayette, Ind.

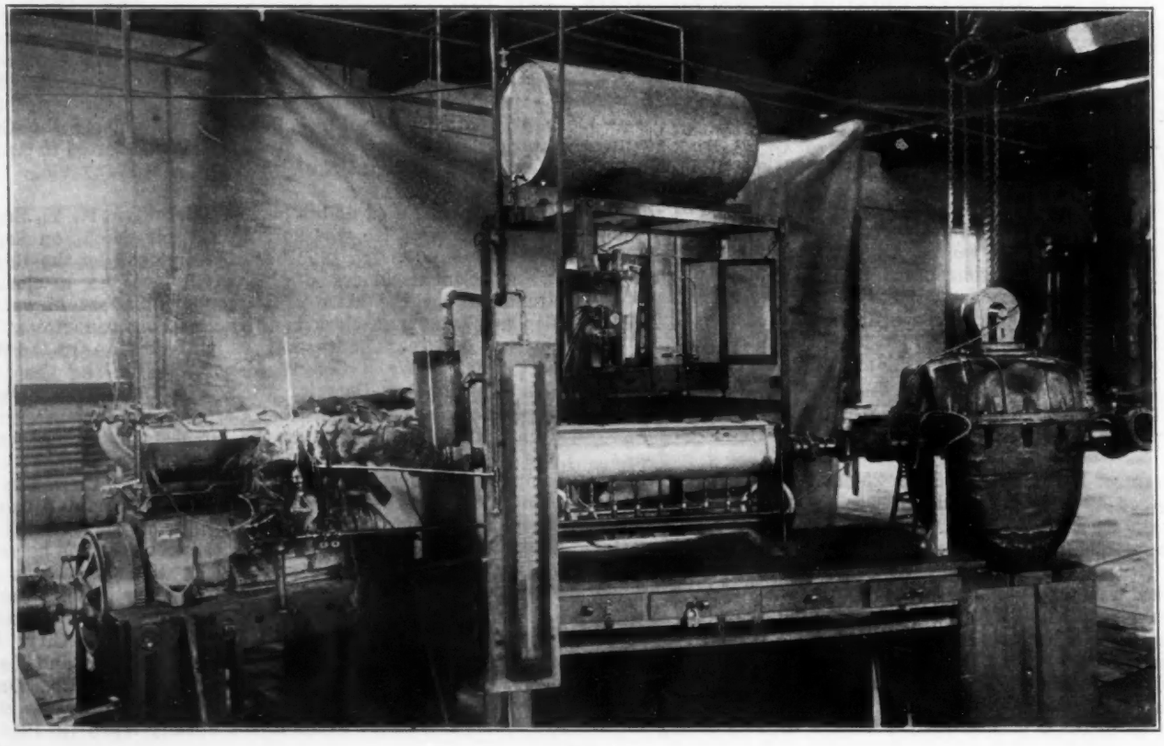


FIG. 1

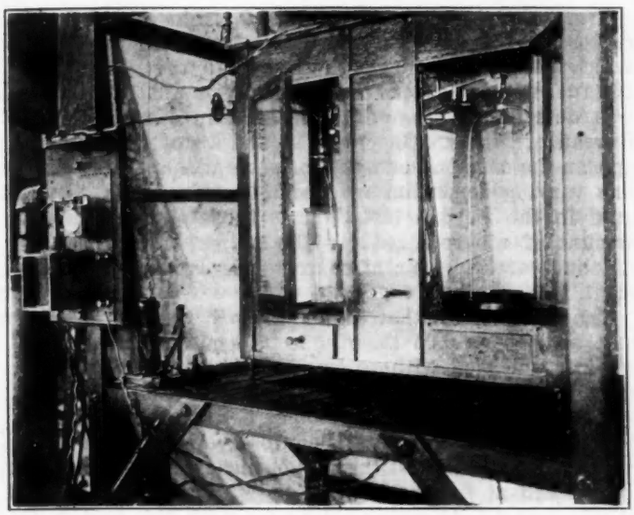


FIG. 2

and curves that form the background for the conclusions will be found in the bulletin referred to.

PURDUE UNIVERSITY TEST APPARATUS

The apparatus used in these tests was described in a paper[3] presented before the Indiana Section in 1916 in which a portion of the present data[4] was also included. This information is, however, so necessary to the purpose of this paper that it is presented again.

The apparatus was designed to give accurate results and to make each test as short as possible, because such a large number of tests are necessary to bring out the desired information. It includes an engine connected to an electrical dynamometer, delicate scales for weighing the fuel, a large diaphragm meter for measuring the air and electrical equipment for starting and stopping the tests. In most of the tests a 4⅛-in. bore by 4½-in. stroke four-cylinder Willys-Knight engine was used. Fig. 1 shows this engine mounted ready for use. Fig. 2 is a more detailed view of the scales and the electrical apparatus for starting and stopping. The speed of the engine was read on a tachometer and checked by stop-watch and revolution counter readings. The torque was weighed by a sensitive scale.

One of the special features was the method of keeping constant the amount of mixture used per minute in each series of tests. It is not easy to set an ordinary butterfly throttle so that it will not move, or in case it does, to reset it in the original position when making check runs. For this reason the throttle was removed and a thin steel plate with a round orifice placed between the carbureter and the intake manifold. The size of the orifice was chosen so that the engine would pull the load at the desired speed when the mixture was properly adjusted. It was found that by keeping the speed of the engine constant and metering the mixture through this orifice, the weight of air used per minute was nearly constant at a constant barometric pressure no matter what the richness of the mixture.

METHOD OF CONDUCTING THE TESTS

The method of conducting the tests was similar in all cases and will be presented in the form of a description of the first series of tests. Here the object was to determine the effect on the performance of an engine of changing the fuel to air proportions. The orifice placed between the carbureter and the manifold was of such size that when the best mixture was used the engine would develop about half of its rated load at 1000 r.p.m., at which speed the tests were then run.

The engine was carefully warmed up and the carbureter adjusted to provide a good pulling mixture. The air entering the carbureter was heated to 300 deg. fahr., and the cooling water at the outlet to 200 deg. fahr., and the dynamometer scales balanced. The gasoline beaker was then filled and the readings of the various test instruments recorded. When the fuel scale came to a balance, the electrical equipment rang a gong and started the stop-watch, the revolution counter and the hand on the dial of the air meter. A weight corresponding to the amount of gasoline to be used was then removed from the scale pan and the attention of the operators was concentrated upon keeping the temperature of the cooling water at 200 deg. and that of the air entering the carbureter at 300 deg., balancing the dynamometer scales and maintaining a speed of 1000 r.p.m.

When the fuel scales again came to a balance, the recording instruments were electrically stopped and the alarm sounded. The various readings were again taken and the test run ended. The weight of gasoline per pound of air in the mixture, the power and the thermal efficiency of the engine were then computed. The first point on each of the curves shown in Fig. 3 could then be plotted.

The mixture was next made slightly richer by opening the gasoline needle, and the brake load was adjusted to hold the speed at 1000 r.p.m. A second test was made under these conditions and another point on each

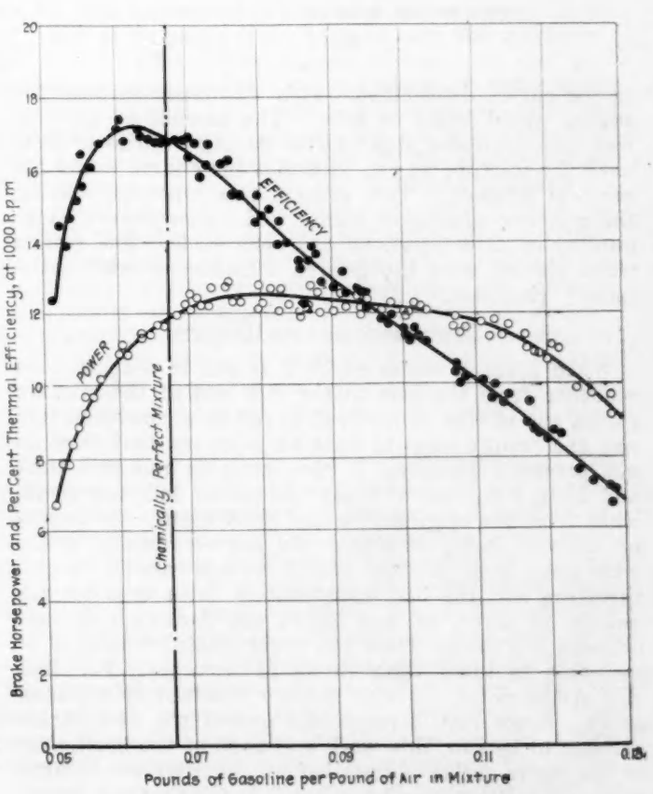


FIG. 3

[3] See S. A. E. Transactions, vol. 12, part 1, page 312.
[4] This information is shown in Fig. 4.

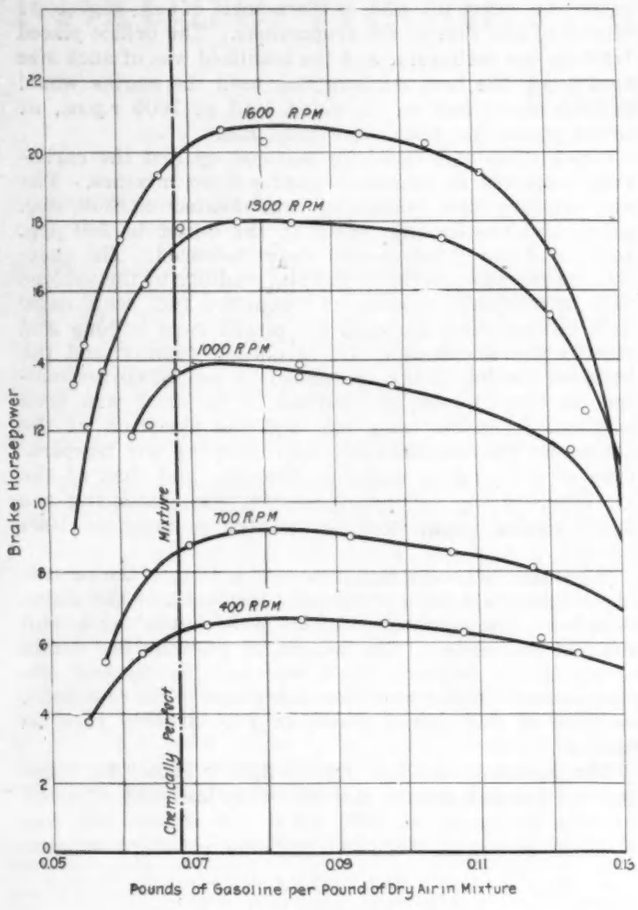


FIG. 4

of the curves determined. This was repeated until the engine would begin to miss. The amount of gasoline was then decreased step by step during a series of tests until the mixture was so lean that the engine would not perform properly. This process was repeated, making the mixture alternately richer and leaner until a large number of determinations had been made. The results when plotted gave the desired information with satisfactory clearness.

DISCUSSION OF THE RESULTS

When a single series of tests is run in a continuous sequence from the lean to the rich end of the mixture range, the plotted points tend to fall in a consistent line and the results seem to have an accuracy that they do not possess. However, if the series is repeated back and forth a number of times, the points will vary somewhat from the original line and show clearly the degree of accuracy being attained. An engine running under what seem to be constant conditions will vary in its performance and the best apparatus is liable to a certain amount of error, so that before any far-reaching conclusions are drawn from the experimental results it is desirable to know their limits of accuracy. For this reason the points in Fig. 3 were obtained as outlined above. Since Fig. 3 represents one of the first series of tests to be run, this work was done at the beginning of the entire series of tests before the observers became so expert as they were later, but it is felt that the errors are never greater than are indicated here.

The vertical line in Figs. 3 to 9, inclusive, at 0.067, represents the chemically perfect mixture, or the one in which there is just enough oxygen in the air to burn the fuel without excess of either fuel or air. This value was determined from data in Bulletin No. 43 of the Bureau of Mines. On pages 18 and 19 of this bulletin appear the chemical analyses of several samples of gasoline varying somewhat in specific gravity, such as was used in the Purdue tests. It is there shown that the amount of air required for the perfect combustion of gasolines of this general character is substantially constant.

The curves show that the engine will run with a mixture as lean as 0.05 lb. of gasoline per lb. of air, but will not pull well with so lean a mixture. The test log shows that misses frequently occur under this condition, but that the performance becomes better as the mixture is made richer, until at 0.055 lb. every cylinder fires regularly. The highest thermal efficiency, 17.25 per cent, is obtained at 0.063 lb., when the engine is developing 91 per cent of its maximum power with this orifice at 1000 r.p.m. The maximum power is obtained with a mixture of about 0.0775 lb. of fuel per lb. of air, at which point the thermal efficiency is 15.4 per cent. The richest mixture that can be fired regularly is about 0.1275 lb., but the engine will function irregularly with mixtures as rich as 0.135 lb. Nearly full load can be carried with a mixture as lean as 0.065 lb. or as rich as 0.115 lb. In other words, a carbureter can be adjusted with as lean a mixture as can be used to carry full load, and the amount of gasoline can be nearly doubled without greatly affecting the power developed or the smoothness of running of the engine. No missing or irregularity of running will appear, and the chief difference in the performance that can be noted is the more rapid combustion with mixtures which approach the chemically perfect mix-

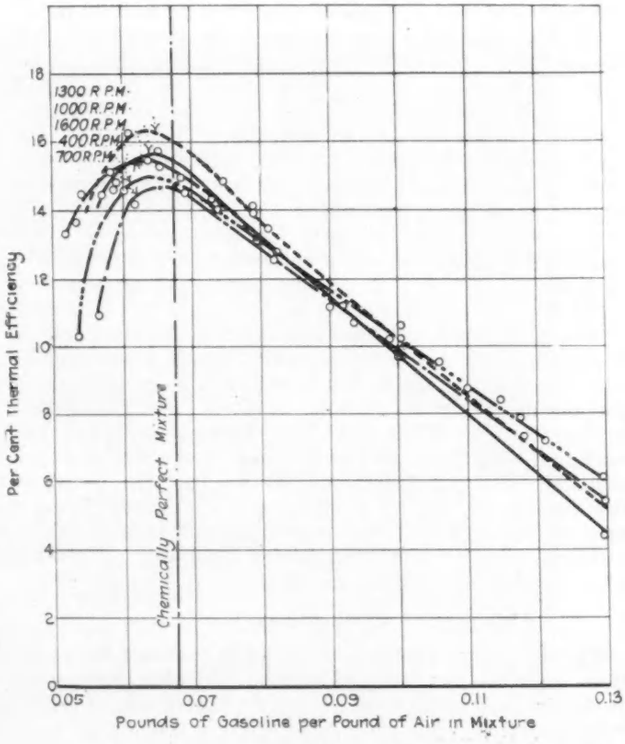


FIG. 5

ture as compared with a very rich or a very lean mixture. A slight metallic knock which disappears as the mixture is made very rich or very lean, is present when a mixture approaching the chemically perfect one is used.

In applying the information obtained from these tests to other conditions, it must be remembered that these results are for half load at 1000 r.p.m., when a warm mixture that was dry as it left the intake manifold was employed. Before applying the conclusions to other conditions one must learn the effect of the load, the speed and the temperature and dryness of the mixture upon the mixture requirements, power and efficiency of an engine.

Effect of Speed and Load

Since the rate of flow of the mixture through the carbureter varies with the speed of the engine, it was necessary to know not only the mixture requirements of the engine at a certain speed, but also the effect of speed upon the mixture requirements. To investigate this point a series of tests was carried out on a Haynes six-cylinder engine. The apparatus arrangement and method of carrying out these tests were the same as in the first series. In this case the engine was run at about half load each time, but at speeds of 400, 700, 1000, 1300 and 1600 r.p.m. Fig. 4 shows the power curves for all the speeds plotted together and Fig. 5, their accompanying efficiency curves.

These tests show that the mixture giving the maximum power is not noticeably affected by the speed, but that at high speeds the engine cannot maintain its power with

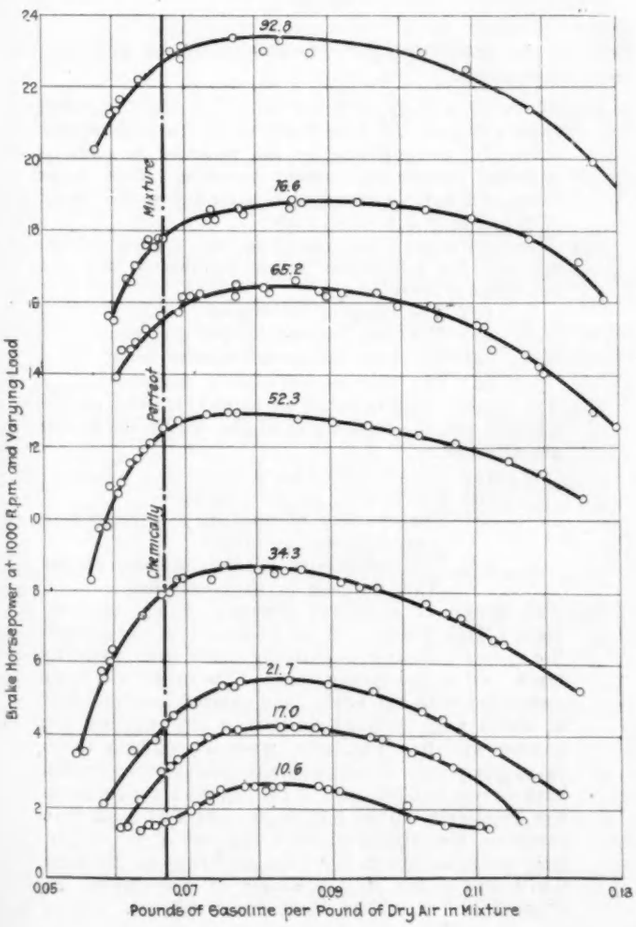


Fig. 6

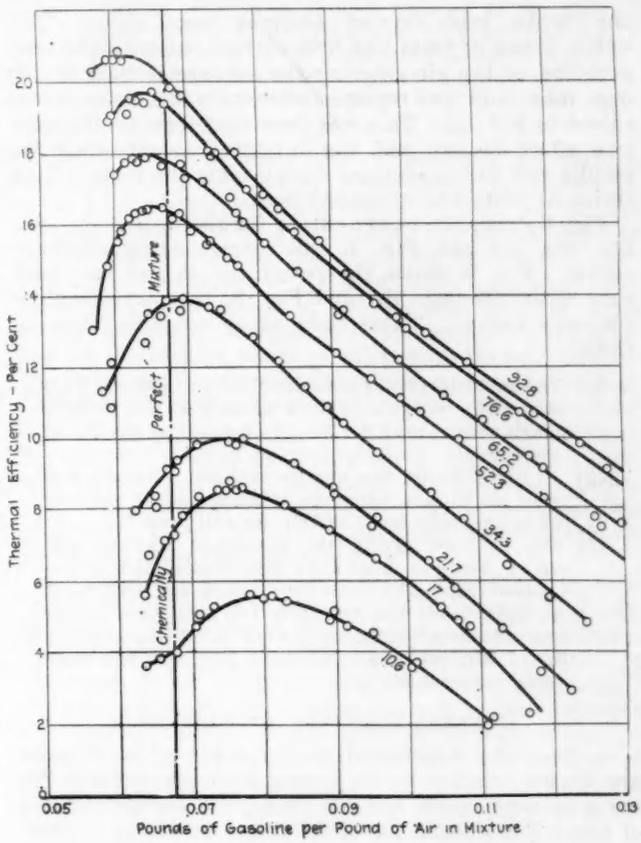


Fig. 7

as much excess fuel or with so lean a mixture as at lower speeds. The latter fact is explained by the slower burning which accompanies very rich and very lean mixtures. The mixture giving the highest efficiency is also unchanged by speed. The practical result of these tests therefore indicates that within the range of mixtures giving the best engine performance, the speed does not affect the mixture requirements of the engine either for maximum power or for the maximum efficiency.

In connection with this series of tests it must be admitted that the apparatus is not sufficiently sensitive, nor is the number of tests large enough to demonstrate conclusively that speed has no effect upon the mixture requirements of an engine. However, they do demonstrate that the effect is not large and it is my opinion that it is very small, so small in fact that carbureter designers are warranted in proceeding upon the basis that engine speed has no effect upon the quality of mixture desired.

Since the rate of flow of the mixture through the carbureter varies with the load carried by the engine, it was therefore necessary to determine the effect of the load upon the mixture requirements. The third series of tests was designed to investigate this point. The apparatus and method of procedure were identical with those just described, except that in this case a separate series of tests was run with each of a series of orifices of different sizes corresponding to different throttle openings. The smallest orifice was just large enough to permit carrying a small load at 1000 r.p.m. the largest one was for full load and the others were for intermediate ones. By comparing the curves obtained from the different series of tests, the effect on the mixture requirements of the engine of changing

the brake load carried becomes very clear. This entire group of tests was first carried out with the temperature of the air entering the carbureter held at 150 deg. fahr., and was repeated later with this temperature raised to 300 deg. This was done to determine the relative effect of dry and wet mixtures as affecting the results and the conclusions drawn from the tests. Both series of tests are presented here.

Fig. 6 shows the power curves for the tests made with 150 deg. air and Fig. 7, the corresponding efficiency curves. Fig. 8 shows the power curves for the check runs with 300 deg. air, and Fig. 9, the corresponding efficiency curves. These tests bring out the following facts:

(1) The mixture giving maximum power does not vary materially with the brake load carried, but remains constant at about 0.0775 lb. of gasoline per lb. of dry air
(2) At light loads, the engine will not operate well with as wide a range of mixtures as it can use when carrying more nearly its full capacity.
(3) The mixture giving the maximum thermal efficiency becomes leaner as the brake load is increased, especially between no load and half load. At light loads the mixtures for maximum power and efficiency coincide at 0.0775 lb. of gasoline per lb. of air, while at full load the best efficiency accompanies 0.062 lb.

General Discussion of Results

In the bulletin referred to a number of conclusions are drawn relative to the richness of the mixture for the maximum power and efficiency. On account of lack of space the reasons for all of these conclusions cannot be given, but the conclusions themselves are of considerable interest and will be presented.

Regarding the richness of the mixture in its relation to the maximum power, the following conclusions seem warranted:

(1) There is a very definite range of fuel mixtures that will give the maximum power in any engine, when the temperature of the mixture is such as to make proper carburetion possible. This range extends a little above and a little below 0.0775 lb. of gasoline per lb. of dry air
(2) The engine requirements as to the richness of the mixture for maximum power production are not appreciably affected by
  (*a*) The speed of the engine
  (*b*) The load carried by the engine
  (*c*) The load of the carbureter used[5]
  (*d*) The type of the engine used[5]
(3) The engine requirements as to the richness of the mixture for the production of the maximum power are affected by
  (*a*) The dryness of the mixture
  (*b*) The quality of the fuel used
  (*c*) The equality of mixture distribution to the different cylinders
  (*d*) The uniformity of the mixture of the fuel and air in each cylinder
(4) The range of mixtures through which approximately full power will be produced is very wide, the richer mixtures containing more than twice as much fuel as the leaner ones. This range will vary somewhat with the brake load carried, being widest at about half load, where with a dry mixture the engine will fire regularly when consuming 0.055 lb. of gas per lb. of air, pull substantially maximum load between 0.065 and 0.115 lb. and continue to fire regularly up to 0.1275 lb. At full load this range is diminished slightly, but at a very light load it is narrowed for regular firing to between 0.070 and 0.095 lb. A study of the curves in Figs. 6 and 8 makes these facts evident.

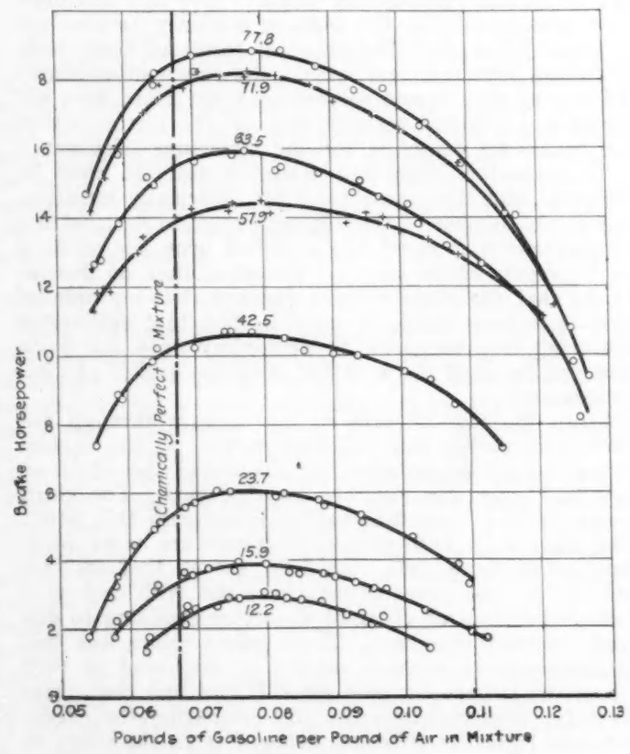


Fig. 8

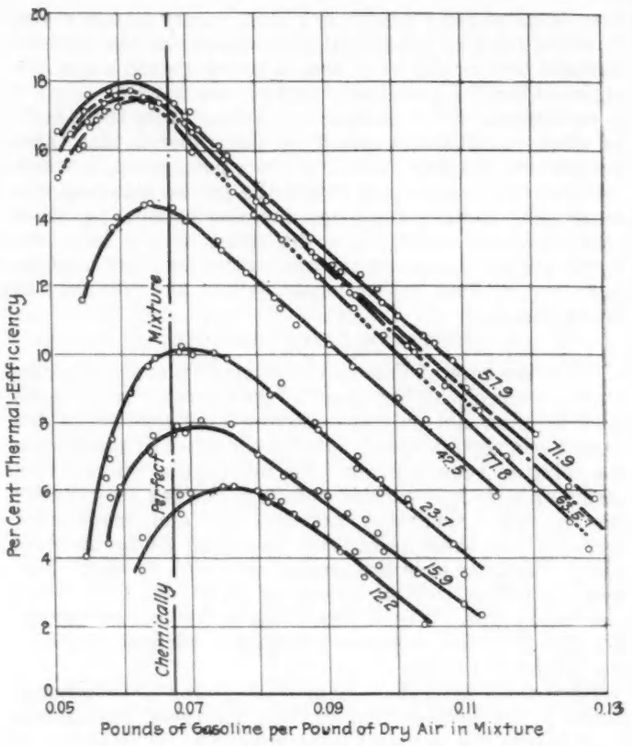


Fig. 9

[5] Unless through the items listed under (3) page 369.

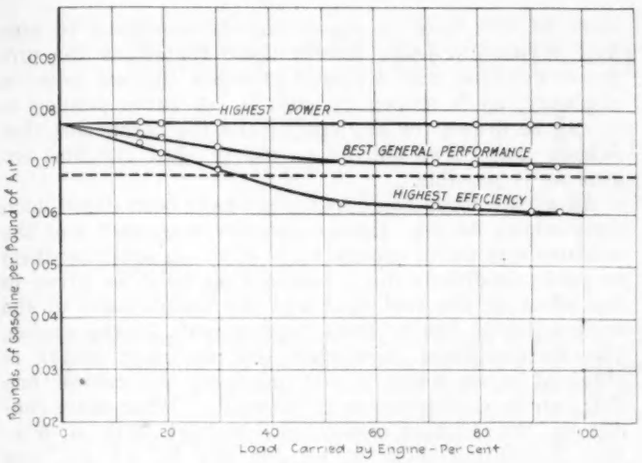

HIGHEST POWER
BEST GENERAL PERFORMANCE
HIGHEST EFFICIENCY
Pounds of Gasoline per Pound of Air
Load Carried by Engine - Per Cent

FIG. 10

In all cases the figures quoted are for warm, dry mixtures. If the mixtures are cold and wet the figures will be higher, and the engine will not run with some of the leanest mixtures quoted here unless both engine and mixture are hot.

A question may well be asked as to why it is that the maximum power is produced when excess fuel is present, rather than with a chemically perfect mixture. Two factors are probably responsible for this. In the first place the fuel is never quite uniformly mixed with the air, so that when the total air and gasoline are in proper proportion some parts of the mixture are too lean. The main reason, however, is the fact that when a rich mixture is used the hydrogen tends to burn in preference to the carbon, leaving a deposit of carbon in the cylinder. The effect of this upon the power of the engine may be understood by its analogy to the case of the combustion of methane, CH_4. The combustion of 1 cu. ft. of methane requires 9.56 cu. ft. of air and will produce, at 32 deg. fahr. and 14.7 lb. pressure, 1072 B.t.u. To burn the hydrogen out of 2 cu. ft. of methane will require the same amount of air but will produce 1392 B.t.u. Thus more power will be produced with the richer mixture.

In respect to the richness of the mixture in its relation to maximum efficiency, the following conclusions seem warranted:

(1) There is a very definite richness of fuel mixture that will give maximum efficiency under given running conditions of the engine

(2) The requirements of the engine as to the richness of the mixture for maximum efficiency are not materially affected by
  (*a*) The speed of the engine
  (*b*) The type of the carbureter used [8]
  (*c*) The type of engine used [8]

(3) The requirements of the engine as to the richness of the mixture for maximum efficiency are affected by
  (*a*) The brake load carried
  (*b*) The dryness of the mixture at the end of the compression stroke
  (*c*) The type of fuel used
  (*d*) The uniformity of the distribution of fuel to the various cylinders
  (*e*) The thoroughness of the mixing of fuel and air in each cylinder

(4) The range of mixtures through which approximately the highest efficiency is obtained is very narrow. This is in distinct contrast to the situation relative to the generation of power and the smooth running of the engine, and accounts in part for the fact that many engines run well and develop good power but prove very inefficient in their use of gasoline.

[8] Unless through the items listed under (3) on this page.

The effect of the brake load carried upon the mixture requirements of an engine when warm dry mixtures are used is represented graphically in Fig. 10. In developing these curves Figs. 7 and 8 were referred to and the mixture giving the maximum efficiency at each brake load was estimated. These brake loads were then expressed as percentages of full load and the lower curve on Fig. 10 plotted to show how the richness of the mixture for the highest efficiency varies with the load carried. The mixture for highest power is a straight line at 0.0775 lb. The middle curve is arbitrarily drawn half way between the other two and is called the mixture for the best general performance. It represents a mixture that will give substantially the maximum power and at the same time approximate the highest possible efficiency. These curves represent the requirements of the engine at a constant speed.

In all of the previous discussion attention has been centered on the requirements of the engine and the conclusions drawn have been modified by the different speeds and loads at which the engine was operated. In designing a carbureter, however, these conclusions must be interpreted in terms of cubic feet of air delivered per minute. Changes in the speed of the engine and the brake load it carries simply vary the rate of flow of the air through the carbureter. Beginning at the smallest flow rate that the engine will require, it is obvious that the volume of air required per minute may be increased either by increasing the brake load at a constant speed, or the speed at a constant brake load or by increasing the load and the speed together. Thus the same engine may require 20 cu. ft. of air per min. with a wide-open throttle at 400 r.p.m. or running light at 1500 r.p.m., yet so far as the carbureter is concerned there will be no change in rate of flow or the mixtures furnished under these widely different conditions. The mixture required for the maximum efficiency of the engine under these two conditions is, however, quite different. With a wide-open throttle at 400 r.p.m. Fig.

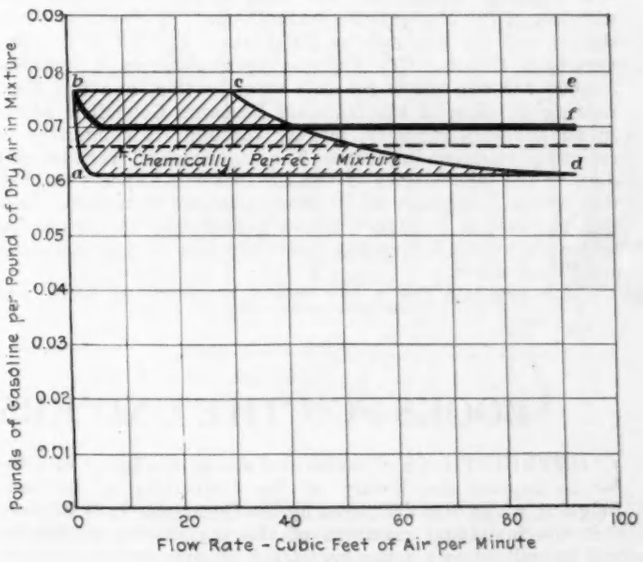


FIG. 11

10 shows that 0.062 lb. of gas per lb. of air will give the greatest efficiency, while at 1500 r.p.m. and no load, 0.0775 lb. of gas per lb. of air is the most efficient mixture. Thus it is impossible for a carbureter to supply an engine with the mixture required for the highest efficiency at all speeds and loads.

Fig. 11 shows the variation in the mixture requirements of an engine for the highest efficiency, in terms of the rate of flow of the air through the carbureter. In this case the engine has been assumed to have a maximum requirement of 93 cu. ft. of air per min. and a speed range of 200 to 2500 r.p.m. This will make the air required for 200 r.p.m. at full load about 9 cu. ft. per min. and 2¼ cu. ft. per min. at no load. Under the latter condition the mixture required for the highest efficiency is 0.0775 lb. This point is marked *b*, Fig. 11. As the speed increases at no load, the rate of flow of the air increases and the mixture for maximum efficiency remains the same. Thus *bc* represents the mixture requirements at no load between 200 and 2500 r.p.m. From *c* to *d* the rate of flow is increased by increasing the brake load at 2500 r.p.m. The shape of the curve is taken from Fig. 10. The curve *ba* is similar in shape to *cd* and represents the change from 200 to 2500 r.p.m. at full load. Thus the shaded area *abcd* shows how much the mixture requirements of the engine may vary at any rate of flow, when the maximum efficiency is attempted.

The mixture requirements for the best general performance may also be indicated on this graph, *bce* representing the mixture for the maximum power, and *bf* that for the best general performance. In connection with *bf* several points should be noted. There is no combination of speed and load where this mixture will not fire regularly if it is warm and dry. With a wide-open throttle this mixture will give substantially the maximum power and at the same time nearly the best efficiency. In the average touring car the engine runs most of the time at approximately one-third to one-half of its full load. Under these conditions the proposed mixture will actually give the highest possible efficiency, as is shown by Fig. 9. A curve similar to *bf* can be drawn for any engine and the carbureter that follows that curve will be as nearly ideal for that engine as is possible.

All of the foregoing conclusions have been based upon tests where 58 deg. Baumé gasoline was used and the mixture was warm enough to be dry. In applying them to other conditions due consideration must be given to the effect of the fuel used and the temperature of the mixture, upon the mixture requirements of the engine. The Purdue tests show that the maximum power is obtained when using a wet mixture, the coldest one that can be carbureted satisfactorily. Under these conditions the highest power is obtained with a mixture containing 0.08 lb. of gas per lb. of air, and at half load the mixture for the greatest efficiency was raised from 0.063 to 0.067 lb. These figures will therefore represent the magnitude of the variation in the mixture requirements of an engine that can be caused by the temperature of the mixture, when the engine is warm enough to run well. When the engine is very cold still richer mixtures are necessary. The excess fuel required will vary with the quality of the fuel and the temperature of the engine. In the very coldest weather the mixture can scarcely be made rich enough to start a cold engine with 58 deg. gasoline.

The results reported here are merely a beginning toward defining the object to be accomplished in carburetion. The automotive industry will do well to recognize the importance of this problem, and the desirability of developing a comprehensive technology of carburetion. The Purdue Engineering Experiment Station will gladly cooperate with the automotive industry in carrying out such lines of work, and will welcome suggestions from any one who is interested.

INVESTIGATION OF FATIGUE OF METALS

AN investigation of fatigue phenomena in metals under repeated stress has just been begun under the joint auspices of the National Research Council, Engineering Foundation, and the Engineering Experiment Station of the University of Illinois. The Engineering Foundation is providing $15,000 for two years for this investigation, and the Engineering Division of the National Research Council is acting in an advisory capacity, largely through its committee on fatigue phenomena in metals. The experimental work is being done in the laboratories of the Engineering Experiment Station of the University of Illinois, under the immediate direction of Prof. H. F. Moore, research professor of engineering materials at the University and chairman of the committee mentioned above.

Plans are laid for a two years' program of tests, and apparatus and material are already arriving for these. It is hoped to secure a considerable amount of data on tests of various metals, including a number of tests of each metal to 100,000,000 reversals of stress. It is planned to study the various short-time physical tests which are used for metals, such as the impact, magnetic analysis and short-time bending tests, to ascertain whether any of these give reliable indices of the ability of the metal to resist fatigue under millions of repetitions of low stress. It is expected that some reliable commercial test for this important property may be developed by this investigation.

A test party of four or five persons is being organized and the University of Illinois is fitting up a special laboratory with about 2500 sq. ft. of floor space for the use of this investigation.

BOOKS FOR THE UNIVERSITY OF LOUVAIN'S LIBRARY

CONTRIBUTIONS of books and money are being solicited to replace the library of the University of Louvain, Belgium, which was destroyed by the Germans. It is believed that the individual members of the engineering profession will be willing to aid the movement by presenting duplicate copies of books from their libraries. Standard works on mining, construction, mechanical engineering, electricity, etc., will be very acceptable. It is not necessary that these books be the latest editions, although ones which are antiquated should not be sent. Contributions can be sent to the Librarian of Congress, Washington, or to the office of the Society. All packages should be marked "For Louvain University."

Vol. V November, 1919 No. 5

Superchargers and Supercharging Engines

By Major George E. A. Hallett,[1] U. S. A. (*Member*)

Annual Meeting Paper *Illustrated with* Drawings and Photographs

THE need for aeronautic engines that will deliver the same power at 20,000 or even 30,000 ft. altitude as they develop at sea level is very real and very great, in not only military but also in commercial aviation. Much success has already been attained with supercharging devices in this country and a certain amount of success in Europe. It must be admitted that there have been some failures also. It is the intention to outline past developments in supercharging in this paper and to point out the lines of attack which seem to be meeting with most success.

Supercharging, as the term is generally used, means forcing a charge of greater volume than that which is normally drawn into the cylinders by the suction of the pistons in conventional internal-combustion engines.

When Supercharging Is Needed

At 20,000 ft. altitude the atmospheric pressure is roughly one-half that at sea level; hence about one-half the weight of charge is drawn into the engine and less

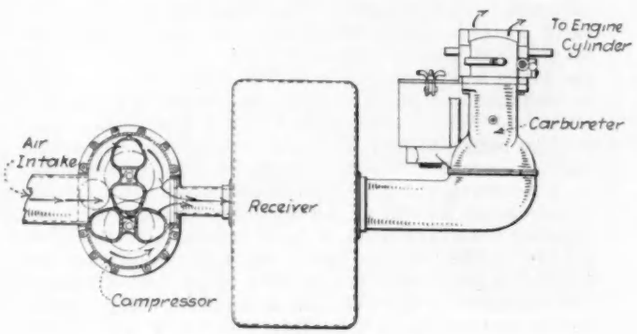


Fig. 1

than one-half the power is developed. At 25,000 ft. altitude less than 25 per cent of sea-level power is delivered. If at these altitudes air is supplied to the carbureter at sea-level pressure, or approximately 14.7 lb. per sq. in. absolute, the power developed by the engine becomes approximately the same as when running at sea level. The low atmospheric pressure and density at great altitudes offer greatly reduced resistance to high airplane speeds; hence the same power that will drive a plane at a speed of 120 m.p.h. at sea level will drive it much faster at 20,000 ft., and still faster at 30,000 ft. altitude, *and with approximately the same consumption of fuel per horsepower-hour.*

There is little to be gained by supercharging at sea level to increase the power of a given size engine, because the clearance volume must be made greater than normal to prevent preignition, with consequent decrease in the expansion ratio and comparatively poor fuel economy. The fact that the clearance volume is increased removes the possibility of the engine developing full power at great altitudes unless a supercharging capacity greater than anything heretofore considered feasible is available. Supercharging, therefore, is most useful in maintaining sea-level horsepower in engines ascending to or working at great altitudes.

Superchargers

Superchargers usually take the form of a mechanical blower or pump and, of course, require a driving gear of some kind. The types of blowers or compressors used to date include the reciprocating, Root displacement and centrifugal types. The reciprocating type was tried by the Royal Aircraft Factory early in the war, on an air-cooled R. A. F. engine, with practically no success. It seems that this type of blower was found to be comparatively heavy and also unsuitable, due to the pulsating pressure of the air delivered.

The Root type blower was tried by the Royal Aircraft Factory with little or no success. The trouble reported was "rough" running of the engine on account of the pressure pulsations in the air discharged by the blower, which tended to overcharge some cylinders and undercharge others, thus causing uneven impulses. It is reported that mechanical troubles also developed with this type of blower. George W. Lewis, of the National Advisory Committee for Aeronautics, is working on an improved Root type blower, shown in Fig. 1. Here the pulsations in the air discharged are synchronized with the suction strokes of the engine. It will be interesting to note how this develops.

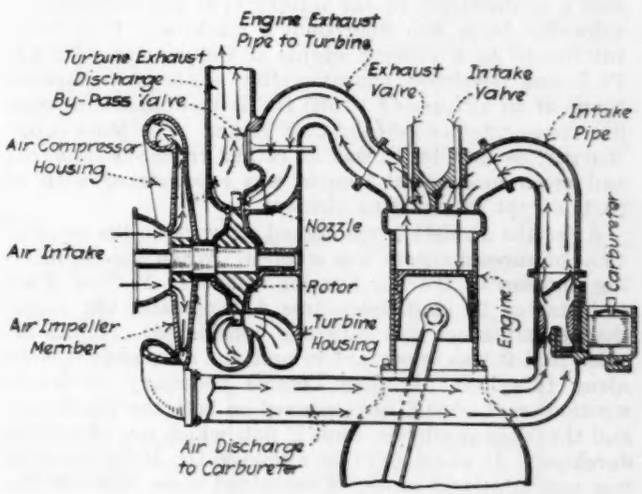


Fig. 2

[1] Chief of powerplant section, engineering division, Air Service, Dayton, Ohio.

The centrifugal type of blower was used by Prof. Rateau, in France, early in the war. He employed the exhaust gases of the engine to drive a high-speed single-stage turbine direct-connected to the centrifugal blower, shown in Fig. 2. Some success was had from the start, but he encountered many mechanical troubles. It is claimed in recent reports that some fairly good results are being obtained by the French.

The Royal Aircraft Factory experimented in 1916 and 1917 with a gear-driven centrifugal blower, but as soon as an endeavor was made to run it at speeds that would stepup the pressure to the 5 or 6 lb. required, great difficulties were encountered on account of the inertia and momentum of the compressor rotor and the high-speed end of the gear-train, which resulted repeatedly in the breakage of the gears when the engine was accelerated or decelerated. To eliminate this trouble a friction clutch, designed to slip under excess torque, was tried, but only partial success was achieved, and the clutch itself gave considerable trouble. Light flexible vanes were then tried on the compressor impeller, but this expedient has not proved successful to date. Similar experiments were conducted by the A. E. F. in France but were concluded by the signing of the armistice.

The United States Air Service started work on the Rateau type of turbo-compressor soon after we entered the war. The work was done under the supervision of E. H. Sherbondy, who worked in conjunction with the Rateau-Bateau-Smoot Co. which handled the Rateau patents in this country, and designed a turbo-compressor which seemingly embodied many improvements over the Rateau type. Three of these machines were built and given ground tests on Liberty engines. The arrangement of the engine and the supercharger is shown in Fig. 3. Considerable trouble was encountered due to overheating of the exhaust-driven turbine, and even the use of a special heat-resisting metal in this part did not overcome the trouble. Soon after Mr. Sherbondy began work on the turbo-compressor, Dr. S. A. Moss, chief of the turbine research department of the General Electric Co., asked permission to carry on some work on the same general type. He built one turbo-compressor which was also a modification of the Rateau type but differed considerably from Mr. Sherbondy's machine. This device was tested on a Liberty engine at the summit of Pike's Peak and developed approximately sea-level horsepower there, at an altitude of 14,000 ft. It was capable of making the engine preignite at that height. The Moss supercharger, as first built, was of rather crude construction, and much mechanical trouble was encountered with all parts except the rotating element.

After the armistice was signed all work on the development of superchargers was stopped. When the engineering division of the Air Service took over McCook Field and started to plan peace-time development, the supercharger situation was carefully considered. It was decided that it was important to continue development work along this line. It then became necessary to decide whether work should be continued on both the Sherbondy and the Moss machines, and, if not, which one should be developed. It was noted that although Dr. Moss' machine was comparatively crude, it contained some inherent advantages over the Sherbondy type, and no way was seen to overcome the faults of the Sherbondy machine. Therefore, the latter was dropped and the General Electric Co. was given a contract to rebuild the old supercharger designed by Dr. Moss. The new device is now being tested in actual flight and giving very interesting results. Figures on the results obtained with the present Moss supercharger are naturally confidential. The indications are that the turbo-compressor is very durable and probably will outlast an aviation engine.

J. W. Smith, a designer and builder of air-cooled radial engines, located in Philadelphia, is known to have designed a turbo-compressor for this type of engine. The B. F. Sturtevant Co. at Boston, Mass., has at least partially developed a belt-driven centrifugal compressor for supercharging one of its aircraft engines.

Carbureter Locations

There is still some question as to the best location for the carbureter in relation to the blower in supercharged engines. Apparently all positions have been tried:

(1) It is possible to use the centrifugal type of blower as a carbureter by placing a fuel jet within its housing and allowing the rotor to do the mixing. As the rotor usually runs over 20,000 r.p.m., it will certainly mix liquid fuel with air. This system would require a manual fuel adjustment, such as is used with the Gnome engine, for different speeds. With this arrangement there would be danger of an explosion in the blower in case the engine back-fire, because the mixture in the blower would be under pressure higher than atmospheric

(2) The carbureter can be placed on the suction side of the blower. In this case the evaporation of the fuel will assist in cooling the charge during compression and the action of the compressor will improve the mixing of the fuel, but the danger from explosion remains to be overcome

(3) When the carbureter is placed in the "normal" position and air is forced through it, it becomes necessary to "balance" the float-chamber with supercharger pressure. This somewhat complicates the feeding of fuel. Pressure gas-feed systems are "banned" in military planes and in any case with a pressure system the tanks would have to be made comparatively heavy to withstand the pressure which would be used at great altitudes. Where gasoline pumps are used it is necessary to regulate their discharge pressure as the plane ascends, because the fuel must reach the float-chamber at a pressure about 2½ lb. higher than that at the supercharger outlet. If the difference in fuel and float-chamber pressures is not kept in constant relation, the quality of the mixture fed to the engine will vary on account of the change in fuel level in the float-chamber. The engineering division has developed a very simple device that solves this problem effectively and is entirely automatic

It would naturally seem at first thought that the extremely low temperatures always found at great altitudes would make possible the easy solution of cooling problems, but in reality the low density of the air reduces its heat conductivity and capacity for heat absorption to such a point that a supercharged engine developing sea-level power at 20,000 ft. requires a little *more cooling surface* than it does when developing normal power at sea level.

The Liberty engine and many others run best with a water temperature of about 170 deg. fahr. To maintain the cooling water at this temperature in the reduced atmospheric pressure at 25,000 ft. it is necessary to use several pounds of air pressure in the radiator to prevent the water from boiling away. Very effective radiator shutters are needed when the engine is throttled to make a descent from altitudes of over 20,000 ft. to prevent the water in the radiator from freezing before warmer air is reached.

Contrary to expectations, the Moss turbo-compressor now being tested at McCook Field does not complicate

the pilot's controls. On a normal engine the pilot handles the throttle and the altitude carbureter control which thins down the mixture as he ascends. With the turbo-compressor the altitude control becomes unnecessary up to the altitude at which the engine can no longer deliver sea-level power but is used, as with a normal engine, if the plane is driven higher.

With the Moss turbo-compressor, when flying at low altitudes, the exhaust pressure is allowed to "waste" through manually operated "gates" in the exhaust pipes. As the plane ascends the pilot closes these gates a little at a time and after he reaches a great altitude he can speed and retard the plane by the use of these gates. He uses the throttle only in case he wants to descend rapidly, when he closes it. In our test flights we have provided the pilot with a sealed altimeter connected only to the supercharger pressure, so that it shows to what altitude this pressure corresponds. When at great altitude the pilot closes the exhaust gates until the pressure in the carbureters causes the altimeter to show sea-level

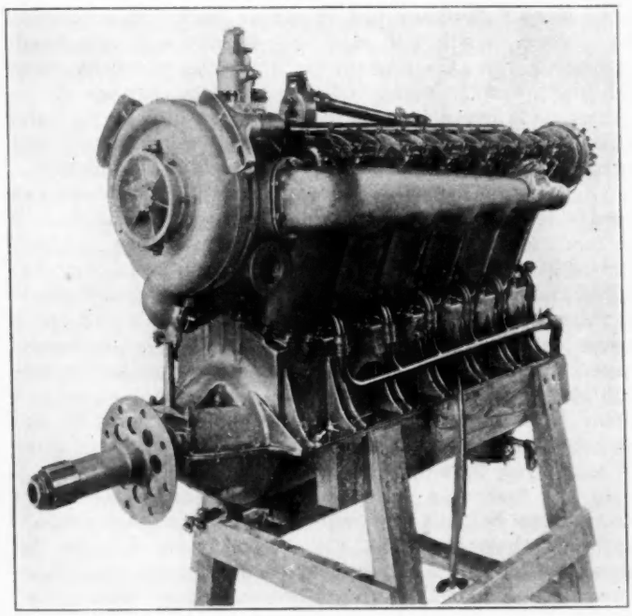


FIG. 3

pressure. This makes it unnecessary for him to do any calculating. If he makes the gage read lower than sea level, the engine will preignite. We have already been able to obtain sea-level pressure in the carbureters at well over 20,000 ft. The exact height cannot be mentioned at present.

With a normal engine the falling off in power as the plane ascends does not cause as much of a drop in propeller speed as might be expected, because of the reduction in density of the air in which the propeller is working. Our best engines do not lose over 75 r.p.m. at 20,000 ft. When an engine is supercharged so that the power remains constant as the plane ascends, the propeller tends to "race" at great altitudes. Therefore it is necessary either to use a variable-pitch propeller or to put on one that holds the engine speed down too low for best performance on the ground but also does not allow the engine to race too much at great altitude. In our present tests we are using an oversize propeller and getting surprisingly good results, but we also have

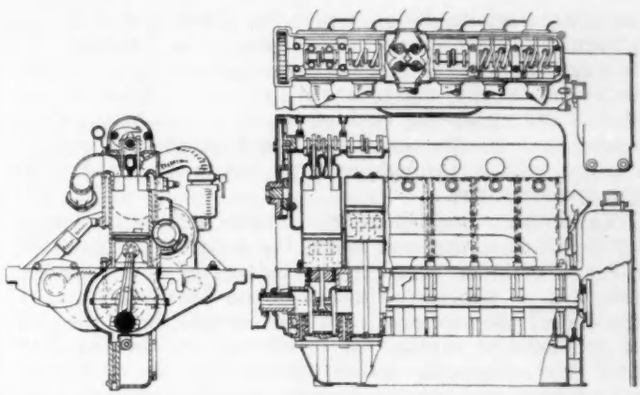


FIG. 4

variable-pitch propellers about ready for test and should get much better performance with them.

SUPERCHARGING ENGINES

As generally used, the term "supercharging engines" refers to internal-combustion engines in which compression in the crankcase or in the lower end of the cylinders is used to force an additional volume of air or mixture into the working cylinders *after completion of their normal suction stroke.* Early in the war the Army and the Navy each placed an order with the Kessler Motor Co., Detroit, Mich., for several experimental supercharging engines. This type of engine, shown in Fig. 4, supercharged each cylinder by the use of crankcase pressure, as is possible in four-cycle engines. Experiments were made using both air and mixture in the crankcase. Considerable difficulty was encountered in both the design and construction of the engine and so far as the engineering division has learned, no complete tests have been run; and in the small amount of testing that has been done no very large increase in power or brake mean effective pressure has been shown officially. It is believed that the frictional losses will prove to be very high in this type of engine and that the supercharging will be comparatively limited. A similar engine which was tested in this country did show very high frictional loss, due partly to the work of operating the valves which controlled the crankcase air.

An interesting problem in this type of engine when using air in the crankcase is whether a rich mixture should be fed through the regular induction system and

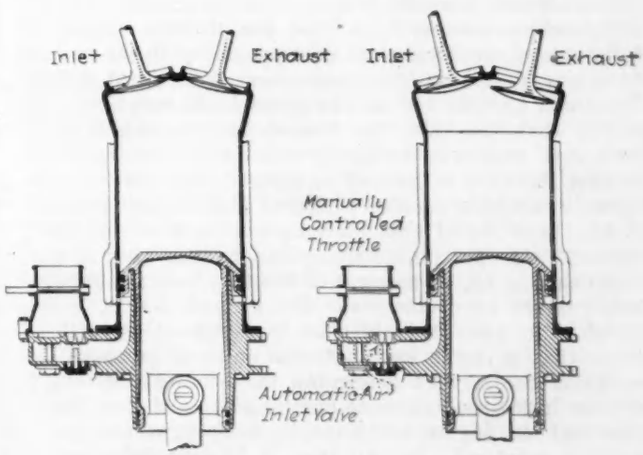


FIG. 5

an effort made to dilute it with the supercharged air, or a normal mixture should be fed through the induction system and an attempt made to obtain perfect stratification and thus let the supercharged air merely form a cool, elastic and expanding cushion on the piston-head. It is feared that in either case it will be difficult to secure the desired results through a large range of speeds and throttle positions.

There is an English make of supercharging engine in which air is compressed under the piston and by-passed through cylinder ports at the bottom of every stroke, (see Fig. 5) supercharging, as in the Kessler engine, at the end of the suction stroke and scavenging at the end of the exhaust stroke. It is claimed by the inventor that this scavenging makes possible the use of higher compression and greatly improves the fuel economy and brake mean effective pressure. It is believed that this engine will give rather limited supercharging and it may prove difficult to control the mixing or stratification of the air and mixture at some speeds.

In an English rotary air-cooled engine the pistons travel out to the cylinder-heads on the scavenging stroke and the beginning of the suction stroke and continue an extra distance inward at the end of the suction stroke. thus taking in a larger charge than that of a conventional engine. The piston reaches only a normal position at the end of the compression stroke and continues an extra distance inward at the end of the suction stroke. all by means of an eccentric crankpin bearing which is rotated on the crankpin by gears of suitable ratio. This type of engine must certainly give a very limited amount of supercharging.

It is believed that supercharging engines will necessarily give a rather limited amount of supercharging. It is also believed that considerable difficulty will be encountered in obtaining the desired stratification in mixing conditions in the combustion chamber through any wide range of throttle positions. Also, some mechanical friction is added in this type of engine and it must be borne in mind that friction is particularly undesirable at great altitudes because it remains nearly constant from the ground up to great altitudes while the power falls off rapidly; therefore, the mechanical efficiency of the engine becomes very low.

The Root type of blower might be interesting for supercharging purposes if the troubles caused by the pulsating nature of its discharge could be eliminated. It is hoped that Mr. Lewis' efforts along this line will meet with success.

It is already frequent practice to build aviation engines with compression so high that the throttle cannot be fully opened on the ground without injury to the engine. In this way, perhaps, the same power is obtained at 5000 ft. as can be obtained on the ground. It has been suggested that this idea be carried further and that an "oversize" engine be built with much higher compression so that the throttle cannot be opened fully until a considerable altitude, such as 10,000 or 15,000 ft., is reached. It has been stated that such an engine could be made lighter, in proportion to the cylinder sizes, than a conventional engine, on account of the fact that the throttle would never be opened near the ground, but it is believed that when this idea is investigated, it will be found that it is the inertia forces quite as much as the explosion forces that determine the necessary strength in most high-speed airplane engine parts and that therefore such an engine could not be built light enough to make it practical. In any case, it is doubtful whether this would give a really good solution for flying at 25,000 or 30,000 ft.

It is possible that centrifugal compressors can be operated satisfactorily by gears or by a belt drive. It is known that some designers are working on both of these problems.

The turbo-compressor in which an exhaust-driven turbine is used for driving the centrifugal compressor, seems to present one fairly good way of accomplishing the desired purpose. The turbo-compressor itself is very simple, as there is only one moving part, namely the rotating element consisting of the turbine wheel and compression impeller. The bearings of this rotating element do not seem to wear noticeably and the device imposes very little drag on the engine when not being used for supercharging. The turbo-compressor is also an effective exhaust muffler.

The Future of the Supercharger

It is believed that when the present type of turbo-compressor now being tested by the engineering division has been more fully developed, it can be built into an engine in a form which will add less weight and less head-resistance than the present machine, and naturally when we know exactly what additional cooling surface is required at a given height, it will not be difficult to build this cooling surface into the airplane in such a form that very little weight and head-resistance will be added.

The uses of the supercharger for military service can be divided into, first, for airplanes in which it is desired to reach extreme altitude; second, for airplanes in which it is desired to increase the rate of climb and horizontal speed and therefore maneuverability at altitudes where it is intended to fight; and, third, for airplanes which carry large loads, such as bombers, which normally are handicapped by having a very low ceiling and whose entire usefulness would, if larger engines were installed to pull them to a higher ceiling, be lost on account of the larger amount of fuel and other material that would have to be carried, thus decreasing their radii of action.

In the first case it is believed that a special supercharger can be built that will make feasible much greater altitudes than any that have been attained with the present General Electric turbo-compressor; and it is considered essential that we have airplanes capable of reaching very great heights. In the second case, it is pointed out that military machines not fitted with supercharging engines, when fighting at an altitude of 20,000 ft. or more, are so near their ceiling that their rates of climb, speed and maneuverability are comparatively poor, but the use of a supercharger seems to overcome this difficulty easily. When a pilot climbs with a normal engine to 20,000 ft. and then levels off in horizontal flight, the engine and propeller speed up perhaps 100 r.p.m. This, of course, enables the engine to develop slightly more power. In the case of a supercharged engine, especially with the turbo-compressor type of supercharger, as the engine speeds up in horizontal flight, the temperature of the exhaust and the power available from the exhaust increase, thus building up the supercharging pressure and giving considerably greater increased power than with a normal engine.

The use of superchargers in commercial airplanes of the future is assured because superchargers will make possible far *more miles per hour* and *more miles per gallon* with a given engine and airplane, and speed is the main advantage of air over other kinds of transportation. It is thought by many qualified judges that by flying at

a sufficient height with a supercharged engine and a suitably designed airplane, a speed of 200 m.p.h. can be maintained.

In the heavy-load-carrying type of plane which must necessarily cross mountains or perhaps fly above storms and clouds, the necessary height can be reached with smaller, cheaper and more economical engines if they are fitted with superchargers. It is obvious that in really long cross-country flights or trans-continental flights, with mail or passengers, the logical course is to fly at 25,000 or 30,000 ft. altitude where the resistance to speed is low and great speed can therefore be attained provided the engine can deliver high power economically, which it can do if equipped with a supercharger.

As a graphic illustration of the advantage of a supercharged engine, it is pointed out that at 25,000 ft. altitude a supercharged 250-hp. engine will deliver as much power as a 1000-hp. engine without a supercharger; and of course the former will weigh many hundred pounds less, its fuel and tankage will weigh very much less, the first cost will be much lower and the structure of the airplane can be made much lighter.

AIRSHIPS AND THEIR COMMERCIAL POSSIBILITIES

(*Concluded from page 352*)

get around or avoid the very worst conditions. Fortunately, the weather conditions over the Atlantic at any season are such that the storm center of any disturbance moves slowly in relation to the actual speed of the winds around it. Even with a ship that can make only 50 m.p.h. and which encounters a 60-mile wind, this would not be so bad, because its speed is sufficient to avoid the storm itself, if the storm center location and how it is moving are known, though not enough to progress against the 60-mile wind. In airship navigation we must lay out our course to avoid the worst weather conditions and take advantage of the good ones as we go along; it is not a matter of following a predetermined line. Altitude always enters as a factor because the wind varies at different heights and we choose that which gives the best results, within the limits, of course, of reasonable economy of gas and fuel.

QUESTION:—What would be the maximum altitude with ships up to 1,000,000 cu. ft.?

MR. UPSON:—The Zeppelins of that size can reach about 20,000 ft., but only with a very light load, as when most of the fuel and bombs are used up. In a passenger ship we could not go very high at the start because we want to carry all the load possible. Altitude means a sacrifice of load, and it is safer not to go to a greater altitude than that at which the balloon is full; but if the ship is forced up that difference in the load must be in a dispensable form so that it can be let out before landing, for there is no known way to land a very heavy airship successfully. Without sufficient lift there will be an accident if anything goes wrong, so we always try to get a little bit light before landing. I might say that this was the whole reason it took us so long to land here. We had too big an allowance of surplus lift, so we just had to readjust it a little at a time until we got it about right. Another time I think it will be easier.

QUESTION:—Do you fly as high as 10,000 ft.?

MR. UPSON:—This little ship we came in today is only capable of about 8000 ft. It is possible to design ships that will fly at almost any altitude by making them large enough. The larger Zeppelins are said to have gone considerably over 20,000 ft. on various occasions, and it would not be hard to design a ship for 30,000 ft. It is simply a matter of design. For commercial use there is no need for going to such extreme altitudes. It is not our object to go up in the air but to get somewhere. Altitude is just incidental to reaching a destination.

QUESTION:—Do you not get more mileage by going up?

MR. UPSON:—It depends upon the weather. In a calm we would get a little more air speed by going up but would lose more in the sacrifice of fuel carried than we would gain by fuel economy. The wind makes the biggest difference.

QUESTION:—Is helium gas explosive?

MR. UPSON:—No. For that reason it is a very fine thing for military use; in fact, it is necessary for any purpose like bombing. Helium is essential for bombing, but for commercial use I believe there is little danger in the proper use of hydrogen, which is cheaper and will lift more.

QUESTION:—Is there any mechanical construction on the inside of the bag?

MR. UPSON:—No, not in this one; that is not any rigid frame. The fins we have been using are all wood, but we are working on a steel construction.

QUESTION:—What is the length of the ship you had up here today?

MR. UPSON:—One hundred and sixty feet, volume 95,000 cu. ft.

QUESTION:—How many were made for the Government?

MR. UPSON:—In this country only about 40 airships, but 1000 or more kite-balloons.

In closing I want to impress one thing upon you again, and that is the enormous advantage of size as applied to airships. If I have accomplished only this I will consider the effort well spent. I have just lately had the good fortune to be a member of a special commission that investigated the state of airship construction and design in the Allied countries. I can say without hesitation that, for their size, American-built ships of the present day are superior to any in the world. If somebody else makes one twice as big he has that great advantage and we are not in it any more, no matter how many refinements of construction we may have. The development of size is the thing America is behind on and we are not going to get anywhere until people wake up to that fundamental fact. When we get the big ships, they will be worth everything they may have cost. Yet they are tremendously expensive to develop, build and handle to start with. It means that we will just have to recognize that fact and steer in the right direction to accomplish what otherwise we never could: compete with foreign nations like England, Italy, France and Germany, all of which are making much bigger airships than we and encouraging the commercial development of still larger sizes.

The Design and Construction of Diesel Engine Fuel-Pumps[1]

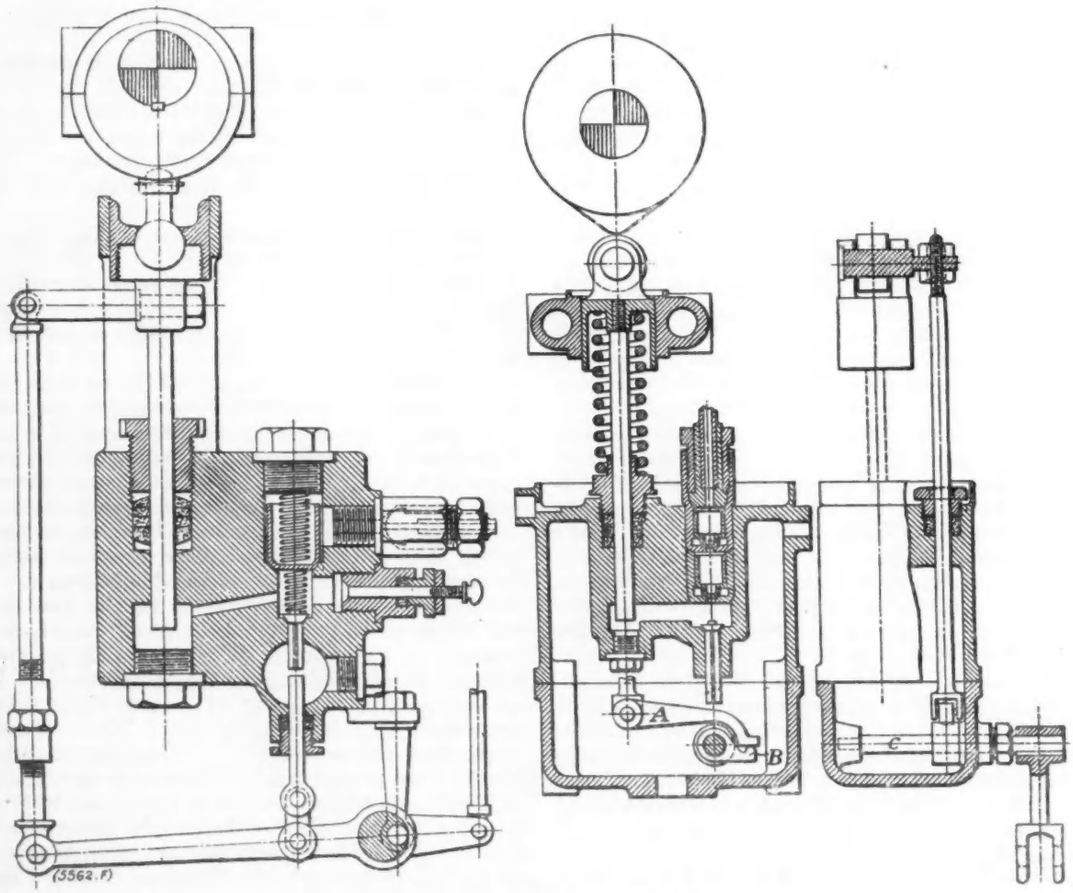
By G. L. Kirk (*Non-Member*) *Illustrated with* Drawings

THE functions of the fuel-pump of a Diesel engine are to deliver the oil fuel to the injection valves on the cylinder and to control the speed of the engine to suit varying loads by regulating the quantity of oil delivered. This delivery has to be effected against the pressure of the blast air, which varies between 750 and 1000 lb. per sq. in. At the same time the volume of oil which has to be handled is very small, and the variations between full load and no load almost minute; hence it can be understood that the mechanism must be extremely sensitive. To insure satisfactory results under these conditions both the design and the workmanship must reach a very high standard.

In multi-cylinder engines the following different arrangements are adopted by various builders of Diesel engines in connection with the general scheme of distribution of oil to each cylinder:

(1) One fuel-pump that delivers oil to a common fuel pipe from which the oil is delivered to each injection valve through a distributing box on each cylinder. These distributing boxes contain a metal diaphragm perforated by a small hole, each one being graduated during the trials of the engine to insure the same amount of oil being delivered to each injection valve. Each diaphragm has a hole of different size to compensate for the drop in pressure in the common pipe due to the varying distance of the diaphragms from the source of supply and to internal friction, etc. This method, involving only one fuel-pump, is cheap to construct and embraces the minimum number of valves and glands to keep in order, but the system is seldom adopted in modern engines owing to the difficulty of obtaining an even distribution of fuel

[1]From an article in a recent issue of *Engineering* (London).



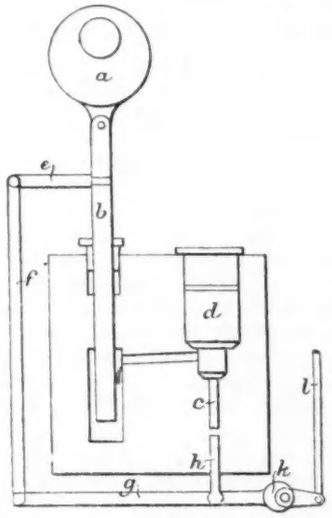
Cross-Sectional Elevations of Two Fuel-Pumps

The Pump at the Left Represents Current Practice with a Right- and Left-Hand Nut on the Driving-Link to Adjust the Clearance between the Tappet and the Suction Valve. The Other Is a Variation from the Conventional Design as the Plunger Is Driven by a Cam Instead of an Eccentric and Is Returned by a Heavy Spring.

to each cylinder, especially at varying loads, the result being that the work is not divided evenly among the cylinders.

(2) The second method, adopted by a few designers, is to supply a separate fuel-pump for each cylinder. This system insures a perfect adjustment of the supply of oil fuel to each injection valve, but necessitates a somewhat cumbersome and complicated driving and control gear and is seldom made use of in modern engines.

(3) The third system is a direct modification of the last one, all the pumps being cast in block and each plunger driven by a separate eccentric or crank through an overhead crankshaft, with each crank set in its proper position relative to the main engine so that the pumps deliver the fuel at the correct period of the stroke. This arrangement is very neat, convenient and accessible; the pump can be placed in the most suitable position, and the control gear is simple. This system is almost universally used on all large marine engines.

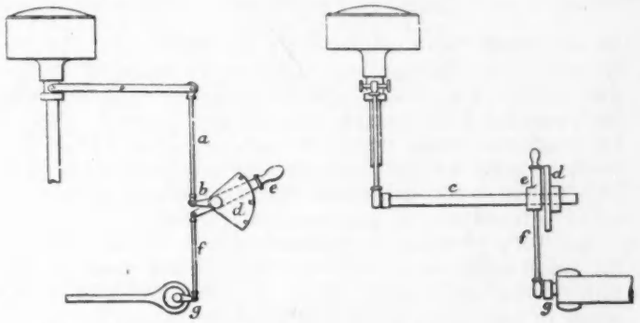


Diagrammatic Sketch of a Fuel-Pump and the Control Mechanism

(4) The fourth system also consists of pumps all cast in block, one for each cylinder, but the plungers are driven from a common cross-head in the case of three or four-cylinder engines and in groups of three from two cross-heads in a six-cylinder engine. Sometimes in the case of four-cylinder engines, the plungers are in two groups, driven by two cross-heads. In the latter cases one group is on the bottom center, while the other group is on the top center. This system simplifies the driving gear, only one or two eccentrics being needed, but care must be taken that no pump is delivering its charge while the fuel injection valve is opening. The control gear is also simple and convenient in this case, and the system is usually employed on small engines.

System of Regulation

Practically the same method of controlling the fuel delivery is adopted in every make of engine. Upon first consideration it might be thought that the volume of the pump delivery could be regulated by varying the stroke of the plunger, in which case the maximum quantity of oil required would constitute the total plunger displacement; but this is not practicable because of the very small quantity of oil required, which would necessitate



A Suggested Scheme for Stopping the Engine by a Hand-Control Lever or the Governor Gear

an extremely small plunger with a very short stroke, in which case a small air bubble under the plunger would prevent it pumping, and there are other obvious disadvantages.

Taking the case of an engine developing 50 hp. per cylinder at 300 r.p.m., with a fuel consumption of 0.42 lb. per b.hp.-hr., the quantity of oil for one stroke of the pump would be

$$\frac{50 + 0.42}{60 + 150} = 0.0023 \text{ lb. or approximately } 0.07 \text{ cu. in.}$$

In the method adopted the pump is designed to deliver three or four times the quantity of oil required but the suction valve is held open by a tappet attached to the regulating lever for a certain portion of the delivery stroke. The excess oil is pumped past the suction valve until the latter is allowed to close by the controlling mechanism when the useful stroke of the plunger commences and oil is delivered to the injection valves. The quantity of oil is varied by altering the period during which the suction valve is held open, thus regulating the useful stroke of the plunger.

A diagrammatic sketch of a fuel pump and its control mechanism is reproduced. The plunger *b* is driven by the eccentric *a*, *c* is the suction valve and *d* the delivery valve. Rigidly attached to the plunger is an arm, *e*, by which the tappet *h* receives its motion through the links *f* and *g*. It will be seen that when the plunger *b* is at the top of its stroke, the tappet *h* also will be in its highest position, holding the suction valve *c* off its seat. As the plunger moves down, the tappet will also receive a downward displacement until it clears the suction valve, when the remainder of the stroke will deliver the oil past the valve *d*. The point of the stroke at which the suction valve *c* closes depends upon the initial clearance allowed between the tappet *h* and the valve-stem. This clearance is effected through the link *g* which is attached at its fulcrum to an eccentric shaft, *k*. The necessary displacement of the eccentric is derived from the governor or control handle through the link *l* and a bell-crank lever so that as the fulcrum point *k* is moved up or down the clearance between the tappet *h* and the valve is varied.

Another type of pump found on some stationary engines has the tappet driven by a separate eccentric, set at an angle to the plunger eccentric, which necessitates a different procedure in the calculations. As the design is practically never met with in marine engines, the details need not be entered into here.

Constructional Details

It will be seen from the foregoing statement how sensitive the regulating mechanism of the Diesel engine must

be to insure rapid adjustments in speed; also the necessity for eliminating any tendency to back-lash in the link mechanism. All pin joints should be of ample size with case-hardened and ground pins working in hard steel bushings accurately ground to size. All links and levers must be rigid enough to avoid any tendency to spring. The suction-valve stem and the tappet rod should be case-hardened with a good area of contact.

The body of the pump is usually of cast iron, except for small sizes, when brass is used. Close-grained cast iron of the best quality should be used and great care taken in casting to avoid blowholes or spongy metal, as the valve seats must be perfect.

The plunger is usually made of high-grade steel; sometimes of case-hardened mild steel. If the plunger is too soft it will wear very appreciably where it passes through the gland, when trouble will be caused by leaking. The plunger is secured to a cross-head guide, driven by the eccentric, the cross-head having a rigid arm attached to it for driving the tappet rod through the links. The plunger rod must be stiff enough to resist bending and can be treated as a long column and checked by Euler's formula.

Plenty of clearance should be allowed between the top of the pump and the cross-head to allow the gland nut to be lifted sufficiently to repack the plunger gland without taking the pump to pieces, a point not always observed.

The suction valve should be case-hardened or made of high-grade steel, and is usually of the mushroom type, the delivery valve being of the thimble type, usually of nickel steel. In some cases two delivery valves are fitted in tandem, since, if there is only one and it should leak badly, the blast air pressure would blow back into the pump and put an unnecessary pressure on the suction valve during the suction stroke. This would strain the regulating mechanism and blow air past the suction valve into the oil chamber, thus forcing the oil out of the pipes and stopping the engine. If only one delivery valve is used, a non-return valve should be fitted on the fuel delivery pipe at the injection valve. The valves should be located in the most convenient position, well clear of the plunger, to allow them to be ground in when in place.

A small hand plunger is usually fitted to enable the piping and injection valve to be primed before starting. It is also useful for testing the valves before running the engine to see that they are in working order. A small vent-cock should be fitted over the delivery valve to get rid of any air and also to test the working of the pump.

The fuel pipes are usually made of steel, since this is not attacked by the fuel as readily as copper. All connections should be of the cone type. There is usually a small strainer of very fine mesh connected to the pump on the main fuel pipe, but this is only additional to the usual working strainers. Efficient straining of the fuel is most important, owing to the necessity for keeping the valve seats in perfect condition.

Control Lever

As it is necessary to stop the engine by a hand-control gear and also to regulate it by the governor gear, a device similar to the following can be used. The governor link *a* is connected to a bell-crank *b* on an intermediate shaft *c* and to this is rigidly connected a quadrant *d*. The hand lever *e* rotates about the shaft *c* but engages with the quadrant in the usual manner, and is also connected to the bell-crank *g*, which is attached to the pump-control shaft by the link *f*. When in running position, the governor transmits its motion to the quadrant and through the latter to the hand-lever and the pump. To stop the engine, the handle is disengaged from the quadrant and rotating on the shaft *c* lifts the bell-crank *g* independently, thus raising the suction valves from their seats and stopping the engine.

By referring to the cross-section through a typical fuel-pump, it will be seen that a right and left-hand nut is provided on the driving link for the regulating gear by which the clearance between the tappet and suction valve can be adjusted. A cross-section through a pump which is a variation from the usual design is also shown. The plunger is driven by a cam instead of an eccentric, the return motion being obtained by a heavy spring. The delivery valves are in duplicate. The driving link for the suction valves is brought to the side of the pump and attached to the arm *A*. The other end of this arm rests on a bell-crank *B*, connected to the horizontal shaft *C*, which in turn is connected to the hand-control lever and governor. By rotating the shaft *C*, the bell-crank *B* lifts the arm *A*, thus altering the clearance between it and the suction valve. The arm *A* acts as the tappet in this case.

CITATION FOR REEMPLOYMENT OF SERVICE MEN

AN official citation is being awarded jointly by the War and Navy Departments to all employers who have reemployed or promised to reemploy all of their former employes who entered the service of the Government. A careful investigation shows that fully 80 per cent, or approximately 3,000,000 discharged service men, went back to their pre-war jobs upon demobilization. As only 38,584 firms, corporations and individuals had been cited up to Oct. 9, the War Department believes that employers generally do not yet know about this citation, which is in the form of a certificate signed by the Secretaries of War and Navy. To secure this citation all that is necessary is that an employer assure the Service and Information Branch of the War Department that he has taken back, or will take back upon their return from service, all men formerly in his employ who left to serve in the armed forces of the United States during the great war. Letters regarding the citations should be addressed to Room 1101, Council of National Defense Building, Washington.

PERSONAL NOTES OF THE MEMBERS

D. M. Ackerlind has accepted a position as designer in the railway motor car department of the Fairbanks Morse Co. in its Sheffield plant at Three Rivers, Mich. He was formerly chief draftsman in the tractor department of the Velie Carriage Co., Moline, Ill.

Walter O. Adams has been elected president and general manager of the Production Foundries Co., Ann Arbor, Mich. He was formerly engaged in the practice of consulting engineering at Detroit, Mich., and specialized in production sales work.

Ralph S. Allen has been appointed general manager of the Duratex Co., Newark, N. J. He was formerly field sales manager for the Wagner Electric Mfg. Co., St. Louis, Mo., with headquarters at Detroit, Mich.

D. E. Anderson has resigned as production engineer with the Hudson Motor Car Co., Detroit, Mich., and has been appointed chief engineer of the Sunnyhome Electric Co. division of the General Motors Corporation, also of that city.

Paul Arthur has been promoted from staff engineer to supervisor of industrial engineering with L. V. Estes, Inc., Chicago, Ill.

W. E. Barton has been discharged from service of the Motor Transport Corps with the rank of captain and is now associated with the Remy Electric Co., Anderson, Ind. During the war Mr. Barton was in command of one of the mobile repair shops of the American Expeditionary Force in France.

A. C. Bigelow has been discharged from the Motor Transport Corps, with the rank of first lieutenant and is now at Trenton, N. J.

P. A. Bleakley has been discharged from the Ordnance Department with the rank of lieutenant and has accepted a position as service man for the Pacific Motors Corporation with headquarters at Los Angeles, Cal.

E. T. Boland has accepted a position as chief engineer and factory manager of the Topp-Stewart Tractor Co., Clintonville, Wis. He was formerly factory manager and engineer with the Eagle Mfg. Co., Appleton, Wis.

E. S. Bradfield has been appointed assistant professor of engineering at Swarthmore College, Swarthmore, Pa. He was formerly engaged in designing at Barnesville, Ohio.

R. L. Burd has resigned as president and general manager of the Burd High-Compression Ring Co., Rockford, Ill. He has not made any plans for the immediate future.

Walter B. Burgess has accepted the position of manager with the Texas Motor Car Association, Fort Worth, Tex., and will have charge of purchases, production and sales. He was formerly factory superintendent of the Midland Motor Car & Truck Co., Oklahoma City, Okla.

Sumner E. Campbell has resigned as chief chemist at Tide Water Oil Co., Bayonne, N. J., to accept a similar position with the Associated Oil Co., San Francisco, Cal.

O. F. Carlson has resigned as chief engineer of the Winslow Boiler & Engineering Co., Chicago, Ill., and has accepted a position as engineer in charge of the steam division of the Amalgamated Machinery Corporation, also of that city.

J. B. Childe, who was formerly general manager of the Canton Spring and Forge Plants of the Standard Parts Co., Canton, Ohio, has been transferred to the Perfection Spring division of the same organization at Cleveland, Ohio.

Fred A. Cornell has been appointed manager of the newly organized machinery and industrial appliances division of the sales department of the Timken Roller Bearing Co. For the past three years he has been Eastern representative of the company, with headquarters at Buffalo, N. Y., but in the future will be located at the general offices of the company at Canton, Ohio.

E. L. Consoliver has been appointed director of the department of automotive electrotechnics at the School of Engineering at Milwaukee, Milwaukee, Wis. The department is a new one which has been developed for training automotive ignition, starting, lighting and storage battery repairmen, and several courses of from three months to two years are given. He was formerly assistant professor of mechanical engineering in the extension division of the University of Wisconsin, Madison, Wis.

Frank Dawson has resigned as designing engineer, purchasing agent and factory manager with the Master Trucks, Inc., Chicago, Ill., and has accepted the position of general manager with the Gary Motor Truck Co., Gary, Ind.

Edward A. Deeds, president, Domestic Engineering Co., Dayton, Ohio, has received a special citation from the British Government for valuable work in starting the production of airplanes for this country at a time when neither material nor a staff were at hand.

Robert I. Dick, who has been serving with the American Expeditionary Force in a mobile ordnance repair shop, has been discharged from the service with the rank of sergeant. He has accepted a position in the engineering department of the Hart-Parr Co., Charles City, Iowa.

A. E. Doman has resigned as vice-president and chief engineer of the Dyneto Electric Corporation, Syracuse, N. Y., and has been elected vice-president of the recently organized Doman Development Corporation, also of that city.

W. E. Dugan has resigned as factory manager of the U. S. Motor Truck Co., Covington, Ky., and has been appointed tractor works manager of the Standard Axle Plant of the Standard Parts Co., Cincinnati, Ohio.

Bert B. Fornaciari is manager of the factory of the Wichita Falls Motor Co., Oklahoma City, Okla. This company has taken over the new factory of the Midland Motor Car & Truck Co., with which Mr. Fornaciari was formerly connected as production manager.

Milton D. Frink has been appointed manager of the service station of the Anderson Motor Sales Co., Charlotte, N. C. He was formerly superintendent of the service department of the Dowling Motor Co. of that city.

Alwyn A. Gloetzner, formerly vice-president in charge of sales and engineering of the Covert Gear Co., Inc., Lockport, N. Y., has purchased the majority holdings in the company's stock and has been elected president.

H. S. Graves, who has been sales enginer for the Dayton Tool Co., Standard Pattern Works, Pittsburgh Saw & Mfg. Co., and the Frank Ault Engineering Co., for the past two years, has moved his offices from 979 to 1519 Woodward Avenue, Detroit, Mich.

C. G. Griffin, who was automotive purchaser for the British War Mission in America, is now general manager with F. S. Bennett, Ltd., London, England.

H. J. Guthrie, formerly manager of the Veedol department, Tide Water Oil Co., New York City, has been appointed vice-president and general manager of the recently organized Tide Water Sales Corporation, also of that city. The new corporation has been formed to handle the engine oil and gasoline products of the Tide Water Oil Co. throughout the United States and Canada and Mr. Guthrie will devote his time to the marketing end and general management of the business.

James Guthrie, who served through the war as engineering representative of the Ordnunce Department in the Michigan district, with the rank of major, has been commissioned a lieutenant-colonel in the Reserve Corps.

William G. Henderson, who has been an engineer with the Excelsior Motor Mfg. & Supply Co., Chicago, Ill., for the past year and a half has resigned to accept the position of chief engineer with the Ace Motor Corporation, Philadelphia, Pa.

Van Wyck Hewlett, Jr., has resigned as layout draftsman with the aircraft department of the Ordnance Engineering

Corporation, Baldwin, N. Y., and has been appointed assistant professor of mechanical engineering at the Pennsylvania State College, State College, Pa.

Leonard S. Horner, vice-president, Acme Wire Co., New Haven, Conn., has received a special citation from the British Government for his valuable work as chief of the executive staff in the production of aircraft for this country.

Frank A. Howard has severed his connection with the firm of Dryenforth, Lee, Chritten & Wiles, Chicago, Ill., and is now in charge of the development department which was recently organized by the Standard Oil Co. This department will serve to coordinate the activities of that organization having to do with technical investigation, research, experimental and patent matters. It will not only originate technical and scientific improvements applicable to the company's business, but will develop and test inventions and suggestions for technical improvements of equipment, processes and products which originate within all other departments. Mr. Howard will make his headquarters at 26 Broadway, New York City.

Herbert J. Howerth, who was formerly a service engineer in the employ of the Pierce-Arrow Motor Car Co., Buffalo, N. Y., has accepted a similar position with the Jordan Motor Car Co., Cleveland, Ohio.

Harold D. Hubbard is now president of the Auto-Lite Service Station, Washington. He was formerly New York branch manager of the Electric Auto-Lite Corporation, Toledo, Ohio.

William F. Jennings and Harry J. Lindsley, who have been Eastern and Western sales managers respectively of the Bound Brook Oil-Less Bearing Co., Bound Brook, N. J., have been elected vice-presidents. In spite of the change of title they will continue to supervise sales in their respective territories.

Charles E. Johnson has resigned as manager of the wheel, tire and rim division of the Pierce-Arrow Motor Car Co., Buffalo, N. Y., and is now vice-president of the Johnson Rim and Parts Co., Inc., also of that city.

Floyd E. Kishline has been discharged from the engineering division of the Motor Transport Corps, with the rank of first lieutenant. He has accepted a position with Graham Bros., Evansville, Ind.

R. H. Klauder has resigned his position as sales engineer with the National Carbon Co., Cleveland, Ohio, and is now located at Philadelphia.

G. J. Lang, assistant to the president of the American Bosch Magneto Corporation, Springfield, Mass., recently sailed for Europe to investigate the export field as it relates to the products of that company.

John M. Lansden, president of the Three Point Truck Corporation, has moved his offices from 1790 Broadway to 536 Fifth Avenue, New York City.

F. S. MacGibbon has been appointed production manager of the Marvel Carbureter Co., Flint, Mich. He was formerly factory superintendent of the Zenith Carbureter Co., Detroit, Mich., and resigned recently to accept a position in the engineering department of the Marvel company.

James R. McCallum has accepted a position as designing engineer in the ordnance engineering laboratory at the Holt Mfg. Co., Peoria, Ill. He was formerly chief engineer of the tractor division of the Militor Corporation, Springfield, Mass.

Earl W. McGookin has been appointed sales manager of the automotive division of the Duratex Co., Newark, N. J., and will make his headquarters at 720 Book Building, Detroit, Mich. He was formerly vice-president of the Martin V. Kelly Co., New York City.

George C. McMullen, Pacific coast representative of the Timken Roller Bearing Co., Canton, Ohio, has opened an office at 450 Monadnock Building, San Francisco, Cal.

J. W. Murphy has resigned as chief engineer of the Keene Mfg. Co., Keene, N. H., and has accepted a position with the Ruggles-Klingemann Mfg. Co., Salem, Mass.

Arthur T. Murray, president of the American Bosch Magneto Corporation, Springfield, Mass., sailed recently to visit England, France, Belgium, Switzerland and Italy. The object of this visit is to investigate the sales possibilities of the company's products abroad and to secure information as to the advancement and improvements that may have been made in their manufacture abroad. It is expected that he will be absent at least three months.

Leonard V. Newton, who was formerly superintendent of motor equipment for the Texas Co. at Chicago, Ill., has been appointed general superintendent of equipment and transferred to the company's offices in New York City.

W. T. Norton, Jr., has been made assistant chief of the engineering branch of the Motor Transport Corps. He was a member of the committee that drew the specifications for and of the chassis committee that designed the standard Class B truck for the Army. Mr. Norton supervised the building of the first truck at Rochester, N. Y., and 10 days after the beginning of the work drove the finished truck, the first standardized Army motor vehicle, from the factory to Washington. During the first half of 1918 he saw service with the American Expeditionary Force as civilian technical advisor to the Motor Transport Headquarters at Tours, France. The Motor Transport Corps engineering branch, of which Capt. G. R. Young is chief, will take up an extensive program of research and experimental work, one object of which is the development of standard Government specifications and tests for commercial parts and accessories of motor vehicles. The cooperation of the Society and the Bureau of Standards will be had in this important work. The aid of manufacturers will be enlisted as to suggestions for improvements in the parts of standardized vehicles.

F. Somers Peterson has again taken charge of the business of the F. Somers Peterson Co., San Francisco, Cal. For the past two years he served as a lieutenant in the Naval Air Service.

H. J. Porter, who has been connected with the sales department of the Timken Roller Bearing Co., Canton, Ohio, for the past eight years, has been appointed sales manager, with headquarters at the general offices.

W. B. Powell has resigned as assistant sales manager with John Millen & Son, Ltd., Montreal, Canada, and has accepted a position with the Northern Electric Co., also of that city.

J. L. Quinn, who was formerly district sales manager of the Standard Oil Co., with offices at Los Angeles, Cal., has been appointed assistant to the manager of the refined oil and naphtha department of that company. He is now located at the company's offices in San Francisco, Cal.

James C. Rappleyea has resigned as service manager of the W. J. B. Motor Truck Co., Inc., New York City, and has accepted a similar position in the New York City office of the Graham Bros. Sales Co.

Roswell M. Rennie has accepted a position as superintendent of the machine department of the University of Illinois, Urbana, Ill.

H. R. Roe has entered the employ of the Central Gear Co. branch of the General Motors Corporation, Detroit, Mich. He was formerly draftsman with the Hupp Motor Car Corporation, also of that city.

Radcliffe Romeyn has accepted a position with the American Manganese Co., Philadelphia, Pa. He has recently been discharged from the Ordnance Department with the rank of captain.

C. B. Rose, who has been serving in the Bureau of Aircraft Production, Washington, has been discharged from Government service with the rank of lieutenant-colonel. He has assumed the management of the Universal Tractor Plant of the Moline Plow Co., Moline, Ill.

N. G. Rost, who has been general sales manager of the Duesenberg Motors Corporation since 1916, has resigned and has organized the firm of Rost, Angstman & Griese, Inc., with headquarters at New York City and a branch office in De-

troit, Mich. The new firm is a sales company and will represent several leading manufacturers in the automotive field.

H. P. Schade has sold his holdings in the Schade-Phelps Corporation, New York City, and resigned as president and engineer of that firm. He has purchased an interest in the R. & L. Bearings Co., Philadelphia, Pa., and will make his headquarters in that city.

Louis J. Schneider has been appointed general sales manager of the Clark Trucktractor Co., Chicago, Ill. He was formerly sales manager of the Harrison Radiator Co., Lockport, N. Y., and was stationed at Detroit, Mich.

Walter H. Shutt has resigned as department manager and director of the H. J. Koehler Motors Corporation, Newark, N. J., and has organized the Advance Auto Service Co., also of that city.

Louie W. Silvis has resigned as instructor at the William Hood Dunwoody Institute, Minneapolis, Minn., to accept the position of assistant service superintendent with the Hudson Motor Car Co. of Illinois, with headquarters at Chicago.

Harold H. Smith has resigned as an electrical engineer in the selling division of the Edison Storage Battery Co., Orange, N. J., and is now chief engineer and secretary-treasurer of the recently organized Transportation Engineering Corporation, New York City.

Mark A. Smith has accepted a position as sales engineer in the truck and tractor department of the Midwest Engine Co., Indianapolis, Ind. Before the war and for the past six months he has been in charge of the passenger car lubrication department of the Standard Oil Co., with offices at Chicago, Ill. Mr. Smith is said to have been the first Marine Reserve officer called into service after this country entered the war. He served with the Marines in the Argonne fighting and was promoted from lieutenant to captain.

C. G. Tate. who was formerly chief of the gas engine instruction department of Purdue University, Lafayette, Ind., has accepted the position of district sales manager with the Parrett Tractor Co., Chicago Heights, Ill., and is now located at Kankakee, Ill.

G. Waine Thomas has resigned as mechanical draftsman with the Indiana Truck Corporation, Marion, Ind., to accept a position with the Holt Mfg. Co., Peoria, Ill.

Paul W. Tietsche has accepted a position as chief engineer at the American Die Casting Co., Indianapolis, Ind. He was formerly a tool design checker and squad supervisor at the Nordyke & Marmon Co., also of that city.

H. C. Umbenhauer, secretary and treasurer, Falls Tire Co., Chicago, Ill., has had his name legally changed to H. C. Hower.

Henry M. Van Loon has been discharged from the Army and has resumed his studies in engineering at the University of Detroit, Detroit, Mich.

A. L. Vargha has resigned his position as designer with the Louisiana Motor Car Co., Shreveport, La., and is now located at Detroit, Mich.

J. G. Vincent, vice-president in charge of engineering, Packard Motor Car Co., Detroit, Mich., has received a special citation from the British Government for his work as the designer of the Liberty engine.

C. Roy Watson has entered the employ of the Allen Motor Co., Columbus, Ohio, as an assistant engineer. He was formerly automotive expert at the Milford Ancona Ranch, Milford, Mich.

O. P. Wilson, who has been assistant general manager of the Norma Co. of America for several years, was elected vice-president at a recent meeting of the board of directors.

James G. Zimmerman will have charge of instruction in ignition equipment at the recently established Ambu Engineering Institute, Chicago, Ill. He was formerly engineer of development and research with the Jefferson Electric Mfg. Co., also of that city.

ACTIVITIES OF S. A. E. SECTIONS

SOME of the Sections have announced programs of their meetings for several months in advance. That of the Cleveland Section includes a number of visits to plants in the immediate vicinity of that city as well as the regular monthly meetings. Two joint meetings are announced by other Sections, one for December and the other for January.

At the meeting of the Detroit Section on Oct. 24 the subject of Pneumatic Tires was discussed by the representatives of the Firestone Tire & Rubber Co., the B. F. Goodrich Co. and the United States Tire Co. These papers, it is expected, will be printed in a subsequent issue of THE JOURNAL. At the November meeting, which is scheduled for the 28th, the Automotive Situation in the Allied and Associated Countries will be discussed by C. F. Kettering, C. C. Hanch and H. E. Coffin. Mr. Hanch, who is general manager of the Maxwell-Chalmers Corporation, Detroit, Mich., went abroad at the request of the Federal Government immediately after the signing of the armistice to study conditions and make a report on them. The December meeting of the Section will be held on the 19th. Commander S. P. Fullinwider, U. S. N., will talk on the North Sea Mine Barrage, and it is expected that his address will tell how the design of the new mine was evolved, the mine fleet was created, mine bases at home and abroad were fitted out and a multitude of other preparations made, and how the great mine manufacturing project, one of the greatest of the war, was planned and carried to a successful conclusion in record time, principally through the instrumentality of the automotive industry.

The first of a series of visits planned by the Cleveland Section to plants in the immediate vicinity is scheduled for the afternoon of Nov. 12, when that of the Cleveland National Malleable Castings Co. will be visited. The November meeting scheduled for the 21st at the Hotel Statler will be a symposium on wheels in which representatives of the Automotive Wood Wheel Manufacturers' Association and the Wire Wheel Corporation of America are expected to participate. Four papers dealing with wire, wood, steel and steel felloe wheels are to be presented, and the meeting will be preceded by a dinner. On Dec. 1 and 2 a joint meeting of the Cleveland and Detroit Sections will be held at Akron, Ohio. The members of the former Section will be taken to Akron in automobiles and the Detroit members will travel on a special train. Six papers dealing with various phases of the tire question are scheduled for presentation, and there will be a banquet on the evening of Dec. 1. The members will be the guests of the Goodyear Tire & Rubber Co. and an opportunity to inspect the plant of this company will be afforded. Other plants which it is expected will be visited in the near future are those of the National Carbon Co., Cleveland Automobile Co., U. S. Copper Products Co. and one of the plants of the Springs Division of the Standard Parts Co.

The October meeting of the Metropolitan Section was held on the 9th at the Automobile Club of America. H. C. McBrair presented a paper on Rear Axle Transmissions which brought out considerable discussion. The November meeting is scheduled for the 20th at the Hotel Commodore. This change in time and place was made to afford the members attending the meeting an opportunity to inspect the custom built bodies with which the foreign and domestic cars displayed at the Automobile Salon that is to be held at the Hotel Commodore that week, are fitted. The speaker will be George J. Mercer, a consulting engineer on body design and construction, who will present a paper on the Trend of Body Design. The December meeting of the Section is scheduled for the

18th. The subject is a Method of Analyzing Torsional Vibrations in Crankshafts and the Elimination of the Critical Speeds. This paper will be presented in two parts. J. F. Fox, draftsman in charge of oil engines at the U. S. Navy Yard, Brooklyn, N. Y., will tell what has been accomplished along these lines from a practical point of view, and Prof. F. M. Lewis of Webb Academy, New York City, will present the mathematical side of the subject. At the October meeting of the Section it was voted to hold a joint meeting of the Metropolitan and Pennsylvania Sections. Plans are also under way for a joint meeting with several other Sections as well as the various engineering societies in New York City. At the present time no details of these meetings are available.

The monthly meetings of the Minneapolis Section will be held at the Manufacturers' Club in that city on the first Wednesday of each month. At the November meeting of the Section, which is scheduled for the 6th, E. S. Kinkead, who served with the American Expeditionary Force, will present a paper on Motorized Artillery in the A. E. F. For the remainder of the season tractor subjects will be considered. A portion of each meeting will be devoted to a discussion of the design of the ideal three or four-plow tractor. The subjects will be divided so as to center on a particular part of the tractor for each meeting, and, if possible, will be arranged to supplement the papers presented. At the first of these meetings on Dec. 3 the subject will be Tractor Wheels, and A. W. Scarratt will speak on Iron Wheels. Charles M. Fuller will present a paper on the Caterpillar Drive and a representative of the Grid Iron Grip Co. will describe the company's special type of grip. The other meetings scheduled and the general subjects of each are: Jan. 7, Four-Wheel Drive versus Caterpillar; Feb. 4, Bearings; March 3, Dynamometer Tests, and April 7, Tractor Weights and Drawbar Pulls. The names of the speakers who will present papers at these meetings have not been announced as yet.

The opening meeting of the Indiana Section was held on Oct. 10 and was preceded by a dinner. The speaker of the evening was Col. E. A. Deeds, whose subject was The Engineer in Industry. General Manager C. F. Clarkson spoke of the work of the Sections and their relations to the parent Society. The work which the Society is doing in connection with fuel research and aircraft standardization was also touched upon.

The November meeting of the Pennsylvania Section has been advanced from the regular meeting night, Friday, the 28th, to Tuesday, the 25th, on account of the Thanksgiving holiday. The speaker at that meeting will be O. A. Hollis, who will have as his subject Dynamics of the Conservation of Energy. The regular scheduled date for the December meeting would be the 26th, and on account of Christmas this meeting has been advanced to Dec. 17. The speaker will be A. K. Brumbaugh, assistant engineer of the Autocar Co., Ardmore, Pa., and his subject will be Over and Back. The January meeting, which will be held on the 23rd, will be a joint one with the Metropolitan Section. It is expected that several papers dealing with the Diesel engine will be presented and discussed at this meeting. The February meeting, scheduled for the 27th, will be held at Pittsburgh. This meeting will be along the same general lines as the one held at Wilkes-Barre last June. It is expected that the plant of the Standard Steel Car Co. will be visited in connection with this meeting.

About 150 were present at the opening meeting of the Buffalo Section on Oct. 21, when John Younger, assistant to the president, Standard Steel Car Co., spoke on Flexibility in Organization. Other meetings of the Section are scheduled for Nov. 25, Jan. 27 and March 23. The speakers and their subjects have not been announced as yet.

A complete list of the secretaries of the different Sections is given below:

Buffalo—Roger Chauveau, 1100 Military Road, Buffalo, N. Y.
Cleveland—A. E. Jackman, 1900 Euclid Avenue, Cleveland, Ohio.
Detroit—Ralph H. Sherry, 1361 Book Building, Detroit, Mich.
Indiana—W. S. Reed, 1602 Merchants Bank Building, Indianapolis, Ind.
Metropolitan—A. M. Wolf, 114 East Sixteenth Street, New York City.
Mid-West—C. S. Rieman, Sixty-first Street and Archer Avenue, Argo, Ill.
Minneapolis—C. T. Stevens, 541 Plymouth Building, Minneapolis, Minn.
Pennsylvania—G. W. Smith, Jr., 309 Hillside Avenue, Jenkintown, Pa.

The meeting nights of the Sections as far as known up to time of going to press with this issue are as follows:

Buffalo—Fourth Tuesday in alternate months
Cleveland—Third Friday
Detroit—Fourth Friday
Metropolitan—Second Thursday
Minneapolis—First Wednesday
Pennsylvania—Fourth Friday

WORK OF THE STANDARDS COMMITTEE

THE various divisions of the Standards Committee have been meeting in accordance with the schedule printed in the October issue of THE JOURNAL The work that has been accomplished by these Divisions since the Summer Meeting last June at Ottawa Beach, Mich., will be embodied in a pamphlet that is now in the hands of the printer and which will shortly be sent to the members of the Society. In view of this fact no extended report of the activities of this Committee will be given at the present time.

At the meeting of the Standards Committee which is scheduled for Jan. 6, 1920, at the Engineering Societies Building, New York City, approximately 40 recommendations presented by 14 of the 18 Divisions will be considered. While this is not the greatest number of recommendations that has ever been presented for consideration at a meeting of the Committee, the number of divisions reporting actual results is the largest in the history of the Society. In order that these recommendations may be thoroughly considered and fully discussed it is hoped that all members of the Committee will attend the meeting and be present at the opening of the session which is scheduled for 10 a. m. and be prepared to present their views on the subjects considered.

Applicants *for* Membership

The applications for membership received between Sept. 29 and Nov. 29, 1919, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ADAMS, GEORGE H., sales service engineer, Bock Bearing Co., *Toledo, Ohio.*

ADAMSON, JAMES A., sales manager, Hoosier Auto Parts Co., *Muncie, Ind.*

AINSWORTH, BERTRAM WILLWAY, truck engineer, Locomobile Co. of America, *Bridgeport, Conn.*

ALBERTY, FREDERICK, mechanical supervisor, Master Trucks, Inc., 3132 Wabash Avenue, *Chicago, Ill.*

BATESOLE, DWIGHT E., mechanical engineer, Norma Co. of America, *New York City.*

BATHRICK, C. E., vice-president and general manager, South Bend Motors Co., *South Bend, Ind.*

BATTERSON, D. C., mechanical engineer, Williamson Hydraulic Clutch Co., *Mount Vernon, Ohio.*

BEANS, JOHN F., president, Beans Spring Co., *Massillon, Ohio.*

BECKER, WILLIAM O., mechanical engineer, Standard Parts Co., Walnut and Eleventh Streets, *Cleveland, Ohio.*

BECKLEY, HARRY E., salesman, Beckley-Ralston Co., *Chicago, Ill.*

BERQUIST, OLOF C., aeronautic draftsman, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*

BIDDLE, H. J., assistant inspection engineer, Remy Electric division, General Motors Corporation, *Anderson, Ind.*

BOCK, CARL J., tractor designer, Holt Mfg. Co., *Peoria, Ill.*

BOHN, CHARLES B., president, Charles B. Bohn Foundry Co., *Detroit, Mich.*

BOOR, ARTHUR, engineer, International Fabricating Corporation, *Wilkes-Barre, Pa.*

BORELL, H. W., draftsman E. G. Budd Mfg. Co., *Philadelphia, Pa.*

BRADLEY, EDWIN P., layout draftsman, L. H. Pomeroy, *Cleveland, Ohio.*

BRAMWELL, JOSEPH W., mechanical engineer, American Bronze Corporation, *Berwyn, Pa.*

BRONTHERS, A. H., automobile dealer, 501 North Street, *Pittsfield, Mass.*

BROWN, G. C. SEDLEY, salesman, Colt-Stratton, Inc., 109 West Sixty-fourth Street, *New York City.*

BROWN, WILL H., supervisor, purchasing and materials, Nordyke & Marmon Co., *Indianapolis, Ind.*

BRUNNER, K. C., draftsman, Holt Mfg. Co., *Stockton, Cal.*

BURDICK, JOHN S., vice-president in charge of engineering, Buffalo Body Corporation, 25 Hardwood Place, *Buffalo, N. Y.*

BUSH, PHILIP M., assistant general manager and treasurer, Bush Mfg. Co., *Hartford, Conn.*

BUTTERWORTH, HENRY L., laboratory assistant, Nordyke & Marmon Co., *Indianapolis, Ind.*

CARMAN, G. B., chief engineer, Forest City Machine & Forge Co., 5101 Lakeside Avenue, *Cleveland, Ohio.*

CLOCK, FRED A., chief engineer, Watson Products Corporation, *Canastota, N. Y.*

DAHL, BRUNO, engineer, automotive department, Standard Steel Car Co., *Pittsburgh, Pa.*

DAVIES, THOMAS B., district sales manager, Central Steel Co., *Massillon, Ohio.*

DERRING, JOSEPH L., lecturer in charge of tractor schools and Western sales representative, Hart-Parr Co., *Regina, Sask., Canada.*

DENNIS, HENRY A., automobile engineer, Texas Co., *New York City.*

DICKEY, ERNEST, assistant chief engineer, Domestic Engineering Co., *Dayton, Ohio.*

DICKOVER, I. CLAYTON, production engineer, Maccar Truck Co., *Scranton, Pa.*

DISHMAN, H. C., sales engineer, Raybestos Co., *Hartford, Conn.*

DULL, CURTIS F., service manager, Naval Training Station, *Great Lakes, Ill.*

DYSART, WILLIAM L., engineering manager, Harlowton Grocery Co., Inc., *Harlowton, Mont.*

EASTERLING, KNOX, district representative, Westinghouse Electric & Mfg. Co., *Indianapolis, Ind.*

EKENBERG, B. C., mechanical engineer, American Kron Scale Co., *New York City.*

ELDRIDGE, J. G., draftsman, Duplex Truck Co., *Lansing, Mich.*

ELLIOTT, EDWARD, assistant chief engineer, Osgood Bradley Car Co., *West Worcester, Mass.*

EWART, ELLIOTT S., automobile designer, Denby Motor Truck Co., *Detroit, Mich.*

FASNACHT, H. H., chief engineer, Shafer Bearing Corporation, *Chicago, Ill.*

FENLEY, WILLIAM H., sales engineer, Kerite Insulated Wire & Cable Co., *Chicago, Ill.*

FITZGIBBONS, A. J., district manager, Merchant & Evans Co., *Philadelphia, Pa.*

FLAMAND, K., superintendent, clutch assembly department, Merchant & Evans Co., *Philadelphia, Pa.*

FLANNERY, WALTER R., salesman, Vanadium Corporation of America, 2849 Equitable Building, *New York City.*

FRASER, EDWARD SMITH, sales engineer, American Bosch Magneto Corporation, *Detroit, Mich.*

FRIEDLY, DONALD C., draftsman on chassis layout, engineering department, Winton Automobile Co., *Lakewood, Ohio.*

FUNSTON, FRED C., draftsman, Carroll Engineering Co., *Defiance, Ohio.*

GARDNER, LEVI S., Gardner Carbureter & Brass Works, *Detroit, Mich.*

GEROW, JAMES F., testing engineer, Kelsey Wheel Co., *Detroit, Mich.*

GIBBONS, H. RALSTON, experimental engineer, Hyatt Roller Bearing division, General Motors Corporation, *Harrison, N. J.*

GIDDEY, YORK ROBERT FRAZER, office and assistant sales manager, American Distributing Co., 1201 Book Building, *Detroit, Mich.*

GORLIN, SOL., mechanical engineer, Samuel Gorlin, *Jersey City, N. J.*

GWYNNE, GEORGE R., chief engineer, automotive department, Continental Oil Co., *Denver, Colo.*

HAAS, LLOYD S., engineer, Victory Mfg. Co., Inc., *York, Pa.*

HAGEMAN, DONALD, mechanical engineer, American Cellulose & Chemical Mfg. Co., Ltd., *Cumberland, Md.*

HARDING, S. V., directing engineer, Midwest Engine Co., *Indianapolis, Ind.*

HARRINGTON, W. F., research engineer, Willys-Overland Co., *Toledo, Ohio.*

HARPER, GEORGE W., assistant engineer, Columbia Axle Co., *Cleveland, Ohio.*

HARRISON, R. E., mechanical draftsman, Holt Mfg. Co., *Stockton, Cal.*

HASKINS, EARL A., service manager, Federal Motor Truck Co., *Detroit, Mich.*

HASTINGS, ROGER W., chief engineer, Parker Axle & Products Corporation, *New York City.*

HASKINS, HOWARD B., experimental engineer, Ford Motor Co., *Detroit, Mich.*

HIROKI, TAKEO J., mechanical engineer, American Steel Co., *Waynesburg, Pa.*

HIGINBOTHAM, ARTHUR O., chief engineer, Charles B. Foster & Co., *Worcester, Mass.*

HILDRETH, NED E., general superintendent, Cushman Motor Works, *Lincoln, Neb.*

HOFFMAN, WILLIAM P., chief inspector, Cleveland Automobile Co., Euclid Avenue and London Road, *Cleveland, Ohio.*

HOPKINS, A. R., chief draftsman, Lang Body Co., *Cleveland, Ohio.*

HUBBARD, DENNIS L., engineer, truck division, American Auto Trimming Co., *Detroit, Mich.*

HUESENER, E. H., consulting engineer, Universal Products Co., *Sandusky, Ohio.*

JERNBERG, C. RICHARD, superintendent, Standard Forgings Co., *Indiana Harbor, Ind.*

JOHNSON, CARL E., mechanical draftsman, Domestic Engineering Co., *Dayton, Ohio.*

JOHNSON, MAJOR JOHN O., chief of gage section, Ordnance Department, Sixth and B Streets, N. W., *Washington.*

JONES, JOHN HARVARD, first-class machinist's Mate, U. S. N., *Hampton Roads, Va.*

KEENAN, WILLIAM J., truck engine draftsman, Bethlehem Motors Corporation, *Pottstown, Pa.*

KEELER, RAYMOND W., draftsman and designing engineer, Kelly-Springfield Co., *Springfield, Ohio.*

KEGERREIS, C. S., research engineer, Purdue University, *West Lafayette, Ind.*

KELLY, RAYMOND J. K., automobile race driver, Thomas Kelly & Brothers, *Chicago, Ill.*

KESSLER, E. HARRY, assistant planning engineer, Standard Parts Co., *Cleveland, Ohio.*

KING, LLEWELLYN A., chief inspector, National Motor Car & Vehicle Co., *Indianapolis, Ind.*

KIRCHNER, THEODORE E., draftsman, Cleveland Automobile Co., *Cleveland, Ohio.*

KLINGER, ADOLF F., mechanical engineer, Silvex Co., *South Bethlehem, Pa.*

KLINGER, GEORGE W., engineer of tests, Vibration Specialty Co., 303 Harrison Building, *Philadelphia, Pa.*

KNOWLES, GEORGE F., production manager, Stephens Motor Works, *Freeport, Ill.*

KOELKER, OSCAR H., assistant chief engineer, L. H. Gilmer Co., Tacony, *Philadelphia, Pa.*

LAKE, HARLEY W., mechanical engineer, 126 Hill Avenue, Highland Park, *Detroit, Mich.*

LANTERMAN, LLOYD S., student, University of Southern California, *Los Angeles, Cal.*

LANTZ, WILLIAM M., aeronautical engineering, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*

LARSON, C. M., assistant supervising lubrication engineer, Sinclair Refining Co., *Chicago, Ill.*

LEFAVOUR, HOWARD, principal, automobile school, Providence Y. M. C. A., *Providence, R. I.*

LEGG, WILLIAM F., mechanical engineer, 3657 Broadway, *New York City.*

LEWIS, ROBERT P., aeronautical draftsman, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*

LOCKWOOD, E. H., assistant professor of mechanical engineering, Sheffield Scientific School, *New Haven, Conn.*

MADSEN, THOMAS EVANS, draftsman and layout man, Milburn Wagon Co., *Toledo, Ohio.*

MARCUM, ARTHUR I., draftsman, Holt Mfg. Co., *Stockton, Cal.*

MAY, RICHARD B., head of technical work, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

MERCHANT, ROSCOE C., sales engineer, Covert Gear Co., Inc., *Detroit, Mich.*

MERTINS, WILLIAM R., assistant chief engineer, Mitchell Motors Co., Inc., *Racine, Wis.*

MICHAEL, GUS F., assistant engineer, South Bend Motors Co., *South Bend, Ind.*

MICHELAT, chief engineer, Automobiles Delage & Cie., 138 Boulevard de Verdun, *Courbevoie, France.*

MOBLEY, ROY WAYNE, layout draftsman, Holt Mfg. Co., *Peoria, Ill.*

MOREHEAD, WILLIAM C., president, Great Lakes Boat Building Corporation, *Milwaukee, Wis.*

MULLER, OTTO, mechanical draftsman, International Motor Co., *New York City.*

NIDES, EMANUEL, chief engineer, Standard Steel & Bearings, Inc., *Philadelphia, Pa.*

NIEMANN, RICHARD THORNE, salesman, Autocar Sales & Service Co., 553 West Twenty-third Street, *New York City.*

NOBLE, W. W., secretary and assistant general sales agent, Carbon Steel Co., *Pittsburgh, Pa.*

OCHTMAN, ARTHUR F., service engineer, Van Blerck Motor Co., *Monroe, Mich.*

OGREN, CARL FRANCIS, plant engineer, American Bronze Corporation, 1376 Cromwell Avenue, *New York City.*

OSTROM, CLAUDE C., sales manager, Washington Steel & Ordnance Co., *Washington.*

PALMER, R. A., president, Collier Motor Truck Co., *Bellevue, Ohio.*

PATCH, HARRY M., engineer, Patch Differential Co., *Seattle, Wash.*

PATTERSON, S. J., educator, Board of Education, *Detroit, Mich.*

PERKINS, L. M., chief engineer, Dyneto Electric Corporation, *Syracuse, N. Y.*

PIETSCH, L. W., lubricating engineer, Standard Oil Co., 910 South Michigan Avenue, *Chicago, Ill.*

PIRONNEAU, E., consulting engineer, 1779 Broadway, *New York City.*

PORTER, ROBERT, manager, Jaxon Steel Products, *Detroit, Mich.*

PRATT, WILLIAM HOLLEY, sales engineer, Klaxon Co., *Detroit, Mich.*

PULFORD, H. L., Grace Motors, Ltd., *Winnipeg, Man., Canada.*

QUIGLEY, GEORGE E., district sales manager, Morgan Spring Co., *Worcester, Mass.*

RAUHAUSER, GEORGE C., designer, Packard Motor Car Co., *Detroit, Mich.*

READER, A. W., assistant chief draftsman, Willys-Overland Co., *Toledo, Ohio.*

RIBLET, ROYAL N., vice-president, Riblet Tramway Co., *Spokane, Wash.*

RICHARDSON, F. E., aeronautical engineer, Air Service, McCook Field, *Dayton, Ohio.*

RICHARDSON, FRED. J., assistant engineer, National Motor Car & Vehicle Corporation, Indianapolis, Ind.

ROBERTS, EDWARD K., sales manager, Bush Mfg. Co., *Hartford, Conn.*

ROBINSON, I. R., photographic section head, Naval Aircraft Factory, League Island Navy Yard, *Philadelphia, Pa.*

RUGG, HARRY MELVIN, supervisor of technical instruction, International Committee, Y. M. C. A., *New York City.*

SCHAEFER, WILLIAM H., assistant to the superintendent, Tuthill Spring Co., *Chicago, Ill.*

SCHLACHTER, HENRY, vice-president, Automotive Educational Bureau, 1203 Farnam Street, *Omaha, Neb.*

SCHLICK, PAUL F., draftsman, Minneapolis Steel & Machinery Co., *Minneapolis, Minn.*

SCHWAGER, H. A., designing engineer, 2½-ton artillery tractor experimental shop, Ordnance Department, *Detroit, Mich.*

SEARS, LESTER M., vice-president and general manager, Towmotor Co., Cleveland, Ohio.

SEVIN, ROBERT E., engineer, Maxwell Motor Co., Inc., *Detroit, Mich.*

SHIVERS, PAUL F., electrical and mechanical engineer, Automatic Light Co., Inc., *Ludington, Mich.*

SMITH, GORDON, engineer, Auto-Farmer Co., Chicago, Ill.

SMITH, H. R., designer, Domestic Engineering Co., *Dayton, Ohio.*

SNEAD, IRA SCOTT, sales engineer, Snead & Co. Iron Works, foot of Pine Street, *Jersey City, N. J.*

STAHL, MICHAEL L., experimental tractor engineer, McVicker Engineering Co., *Minneapolis, Minn.*

STAMM, A. C., sales engineer, Raybestos Co., *Bridgeport, Conn.*

STEINFURTH, LOUIS, Jr., checker, engineering department, Cleveland Automobile Co., *Cleveland, Ohio.*

STEWART, JAMES L., patent lawyer, 60 Wall Street, *New York City.*

STOLL, HERMAN, chief draftsman, Willys-Overland Co., *Toledo, Ohio.*

STOLL, L. F., branch manager, Class Journal Co., 823 Widener Building, *Philadelphia, Pa.*

STONE, SELDEN EARL, student engineer, Carpenter Motor Co., *Durham, N. C.*

SRIGLEY, WALLACE, designer, Canadian Products, Ltd., *Walkerville, Ont., Canada.*

SWARTHOUT, G. F., chief engineer, Stearns Motor Mfg. Co., *Ludington, Mich.*

TALBOT, JAMES M., sales manager, S. S. White Dental Mfg. Co., *New York City.*

TANNER, WILLIAM RAYMOND, assistant to the division superintendent, International Harvester Co., *Akron, Ohio.*

TAYLOR, C. L., chief engineer, Morgan Engineering Co., *Alliance, Ohio.*

THOMAS, J. B., supervisor of inspection, Westinghouse Electric & Mfg. Co., *Lester, Pa.*

THOMPSON, C. N., engineer, Chandler Motor Car Co., *Cleveland, Ohio.*

THORNHILL, W. H. T., steel specialist, Midvale Steel & Ordnance Co. and Cambria Steel Co., *Philadelphia, Pa.*

THURSTON, ARTHUR L., aeronautical engineer, Charles B. Kirkham, *New York City.*

TOWNSEND, RALPH H., chief engineer, Hooven Radiator Co., 517 West Monroe Street, *Chicago, Ill.*

TRACHSEL, FRANK C., technical representative, Standard Commercial Export & Finance Corporation, 120 Broadway, *New York City.*

VOGEL, CHARLES R., engineer, American Telephone & Telegraph Co., *New York City.*

WARNER, C. B., chief engineer, Nelson Motor Truck Co., *Saginaw, Mich.*

WARNER, JOSEPH R., chief draftsman, Dyneto Electric Corporation, *Syracuse, N. Y.*

WATERS, EARL M., tool designer, Lincoln Motor Co., *Detroit, Mich.*

WEIHER, GEORGE F., service engineer, Automotive Mfg. Co., *Dayton, Ohio.*

WEINERT, H. F., junior electrical engineer, General Motors Laboratories, *Detroit, Mich.*

WELCH, HOWARD S., foreign sales representative, Studebaker Corporation, *South Bend, Ind.*

WESTMAN, L. A., vice-president and superintendent, Forest City Machine & Foundry Co., 5101 Lakeside Avenue, *Cleveland, Ohio.*

WHITE, RALPH, designing engineer, Edward G. Budd Mfg. Co., Twenty-fifth Street and Hunting Park Avenue, *Philadelphia, Pa.*

WHITNEY, C. PAUL, superintendent of instruction, American Automotive School, *Dallas, Tex.*

WINCHELL, HAROLD B., engineer, William and Harvey Rowland, Inc., Frankford, *Philadelphia, Pa.*

WINKLER, FRED C., draftsman, Bendix Engineering Works, *South Bend, Ind.*

WOODROW, MAURICE R., factory representative, Stokes Carburetor Co., Inc., *New York City.*

WOOLSON, LIONEL M., engineer of tests, Packard Motor Car Co., *Detroit, Mich.*

WRIGHT, LAWSON W., president, Hooven Radiator Co., 517 West Monroe Street, *Chicago, Ill.*

YELM, C. W., general manager mechanical goods division and consulting engineer, Gates Rubber Co., *Denver Colo.*

YENAWINE, W. D., inspection foreman, Oakland service station, *Long Island City, N. Y.*

YOKOYAMA, SHIN MATSU, layout man, Continental Motors Corporation, *Detroit, Mich.*

YOUNG, C. G., John N. Willys Export Corporation, 165 Broadway, *New York City.*

YOUNG, VINCENT C., engineer, International Motor Co., *Plainfield, N. J.*

ZIESENHEIM, FRED C., mechanical engineer, 912 Ross Avenue, *Wilkinsburg, Pa.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Sept. 15 and Nov. 22, 1919. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (E. S.) Enrolled Student; (S. M.) Service Member; (F. M.) Foreign Member.

ANTHONY, ARTHUR H. (A) general manager, Massillon Steel Casting Co., *Massillon, Ohio.*

BAKER, E. J., JR. (A) technical editor and secretary, *Farm Implement News*, 704 Masonic Temple, *Chicago, Ill.*

BEDFORD, FRED J. (M) manager, lubricating department, Magnolia Petroleum Co., P.O. Box 1667, *Dallas, Tex.*

BRISTOW, CLAUDE S. (M) chief engineer and works superintendent, Bailor Plow Mfg. Co., *Atchison, Kan.*, (mail) 321 North Tenth Street.

BROWN, WILLIAM GLADSTONE (A) branch manager, American Bosch Magneto Corporation, 3737 Michigan Avenue, *Chicago, Ill.*

BUTLER, GILBERT (A) secretary and treasurer, Bossert Corporation, *Utica, N. Y.*

BUTLER, WILLIAM L. (J) aeronautical mechanical engineer, engineering division, Air Service, *Dayton, Ohio,* (mail) Box 163, Y. M. C. A.

CARPENTER, W. H. (M) Dean Forging Co., Muncie, Ind., (mail) *Columbia, Conn.*

CHAMPAIGN, DONALD KEITH (M) engineer, Champaign Brothers, *Ithaca, N. Y.*

CHURCH, R. N. (M) engineer, Challoner Co., 29 Osceola Street, *Oshkosh, Wis.*

COGGER, WILLIAM T. L. (M) manager of miniature lamp manufacturing, National Lamp Works of General Electric Co., *Cleveland, Ohio,* (mail) Nela Park.

CONDIT, KENNETH HAMILTON (M) associate editor, *American Machinist*, McGraw-Hill Co., Inc., Tenth Avenue and Thirty-sixth Street, *New York City.*

CORCORAN, EDWARD S. (M) Kelly-Springfield Motor Truck Co., *Springfield, Ohio,* (mail) 357 Arlington Avenue.

DEAN, EDWARD E. (M) field engineer, Byrne, Kingston & Co., *Kokomo, Ind.*, (mail) 1119 North Indiana Avenue.

DENGLER, CLIFFORD HOWARD (J) tool and automobile designer, Fergus Motors of America, Newark, N. J., (mail) 26 Lufberry Street, *New Brunswick, N. J.*

DENT, J. GRANT (A) instructor in agricultural engineering, University of Minnesota, *St. Paul, Minn.* (mail) University Farm.

DIETZ, GEORGE J., JR. (J) assistant engineer, International Fabricating Corporation, *Wilkes-Barre, Pa.*

DYMENT, ALBERT ELLIOTT (E.S.) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 1309 Wilmot Street.

EAMES, HERBERT S. (M) engineer, Northway Motors Corporation, Natick, Mass., (mail) 29 Beech Street, *Framingham, Mass.*

EASTERN MALLEABLE IRON CO. (Aff.) *Naugatuck, Conn.* Representatives: C. L. Berger, vice-president, Eastern Malleable Iron Co., Naugatuck, Conn.; T. Rice Davis, general manager, Bridgeport Malleable Iron Works, Bridgeport, Conn.; E. G. Hurlbut general manager, Vulcan Iron Works, New Britain, Conn.; Emil Mannweiler, general manager, Naugatuck Malleable Iron Works, Naugatuck, Conn.; John E. Walker, general manager, Wilmington Malleable Iron Works, Wilmington, Del.; Walter F. Witman, general manager, Troy Malleable Iron Works, Troy, N. Y.

ELLINWOOD, G. H. (M) technical superintendent, Federal Rubber Co., *Cudahy, Wis.*

ENGBERG, JENS FREDERICK (M) general superintendent, United Automobile Factories, Inc., *Odense, Denmark.*

FISCHER, LAWRENCE W. (J) mechanical draftsman, Continental Motors Corporation, *Detroit, Mich.*, (mail) 369 Hillger Avenue.

GASTON, RALPH M. (M) chief engineer George P. Nichols & Brother, 2139 West Fulton Street, *Chicago, Ill.*

GENERAL ASBESTOS & RUBBER CO. (Aff.) *Charleston, S. C.* Representative: C. Bissell Jenkins, Jr., vice-president and sales manager.

HAGELTHORN, G. (M) vice-president and general manager, Atlas Ball Co., *Philadelphia, Pa.*

HARTMAN, FREDERICK V. (M) mechanical engineer, Aluminum Co. of America, *New Kensington, Pa.*, (mail) P.O. Box 35.

HEDGELAND, MARLEY C. (M) designer, Warner Gear Co., *Muncie, Ind.*, (mail) 1401 Granville Avenue.

HEENA, CARL R. (J) chief draftsman and tool designer, G. A. Schacht Motor Truck Co., *Cincinnati, Ohio,* (mail) Hotel Anderson.

HEGY, CAPT. HARRY S. (S.M.) mechanical engineer, tank, tractor and trailer division, Ordnance Department, Sixth and B Streets, N.W., *Washington.*

HENKEL, HERMAN (M) treasurer and service manager, Wolverine Auto Sales Co., *Lansing, Mich.*

HERBERT, HASWELL C. (J) engineer of tests, Brewster & Co., Long Island City, N. Y., (mail) *Hartsdale, N. Y.*

HERMAN, KENNETH R. (J) chief draftsman, Kimball Motor Truck Co., 1700 East Ninth Street, *Los Angeles, Cal.*

HOLDEMAN, L. H. (M) chief engineer, Dayton Stamping & Tool Co., 346 Xenia Avenue, *Dayton, Ohio.*

HOLLOWAY, J. H. (A) engineering experiment station staff, Purdue University, *Lafayette, Ind.*, (mail) Mechanical Engineering Building, Purdue University.

HOUSE, C. N. (M) service engineer, New Departure Mfg. Co., Bristol, Conn., (mail) 480 Seneca Avenue, *Detroit, Mich.*

HUNT, GEORGE H. (A) sales manager, wheel division, Detroit Fressed Steel Co., *Detroit, Mich.*, (mail) 164 Pingree Avenue.

HUSTON, PAUL W. (A) sales representative, Bock Bearing Co., *Toledo, Ohio.*

IRVINE JAMES ROBERTSON (A) draftsman, Holt Mfg. Co., *Stockton, Cal.*, (mail) 207 North San Joaquin Street.

JACKSON, HENRY W. (M) in charge of development and engineering, miniature lamp department, General Electric Co., *Harrison, N. J.*

KAUFMAN, OTTO H. (A) sales manager, Challoner Co., *Oshkosh, Wis.*, (mail) 15 Central Avenue.

KEELEY, RICHARD W. (A) factory representative, Eclipse Machine Co., Inc., *Elmira, N. Y.* (mail) 368 West Clinton Street.

KESSLER, A. G. (M) vice-president, General Ordnance Co., *Derby, Conn.*

KINNEY, J. S. (M) engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., (mail) 908 Center Street, *Wilkinsburg, Pa.*

KLEIN, SETH C. (A) Western representative, Fedders Mfg. Co., Buffalo, N. Y., (mail) 3233 Ruckle Street, *Indianapolis, Ind.*

KNIGHT, RICHARD G. (M) superintendent, Gray Dort Motors Ltd., *Chatham, Ont., Canada.*

KRAGNESS, EDWARD O. (A) treasurer and engineer, Brown & Kragness, New York City, (mail) Bon Air Apartments, 400 Stanyan Street, *San Francisco, Cal.*

KUIPER, GERHARD C. R. (A) engineer, Jordan Motor Car Co., Inc., *Cleveland, Ohio.*

LAHTINEN, WILLIAM E. (J) mechanical engineer, McVicker Engineering Co., *Minneapolis, Minn.*, (mail) 233 Humboldt Avenue, North.

LANG, WALTER B. (J) assistant superintendent, manufacturing department, Naval Aircraft Factory, Philadelphia, Pa., (mail) *Rutledge, Pa.*

LOUNSBERRY, FRANK B. (M) metallurgist, Atlas Crucible Steel Co., *Dunkirk, N. Y.*

MCCURDY, LYNN H. (A) vice-president, Hercules Gas Engine Co., *Evansville, Ind.*

MCINTYRE, J. J. (A) general manager, Cleveland Graphite Bronze Co., 1084 East 152nd Street, *Cleveland, Ohio.*

MALM, WALTER R. (S.M.) metallurgical engineer, Bureau of Aircraft Production, *San Francisco, Cal.*, (mail) 2424 Steiner Street.

MANN, ROBERT B. (M) engineer in truck and tractor experimental division, International Harvester Corporation, Chicago, Ill., (mail) *Riverside, Ill.*

MELTON, LLOYD L. (M) vice-president and engineer, Single Sleeve Motors, Inc., 814 Hearst Building, *Chicago, Ill.*

MERRITT, HAROLD W. (J) 373 Bergen Avenue, *Jersey City, N. J.*

MITCHELL, R. B. (M) engineer, Alamo Farm Light Co., *Hillsdale, Mich.*

MURRAY, GEORGE S. (J) Murray & Tregurtha Corporation, Atlantic, Mass., (mail) 12 Spafford Road, *Milton, Mass.*

NEWBURY, ROBERT C. (A) engineer, Denver Gas & Electric Light Co., *Denver, Colo.*, (mail) 213 Gas & Electric Building.

NORMAN, CARL A. (M) professor of machine design, consulting engineer and combustion engineer, Ohio State University, *Columbus, Ohio.*

OLIN, R. E. (M) experimental designer, Timken-Detroit Axle Co., *Detroit, Mich.*, (mail) 8 La Mothe Avenue.

OLSEN, GEORGE FREDRIC (M) vice-president, New England Oil Refining Co., 19 Milk Street, *Boston, Mass.*

PARKER, HAROLD WEBSTER (J) draftsman, Hyatt Roller Bearing Co., *Chicago, Ill.*, (mail) 1016 Berwyn Avenue.

PENNINGTON, CAPT. G. R. (M) resident engineer and manager of Cleveland engineering office, Ordnance Department, *Cleveland, Ohio,* (mail) 8932 Euclid Avenue.

PHILLIPS, DOUGLAS L. (J) Smith Brothers, *Los Angeles, Cal.*, (mail) 434 South Park View Street.

PORTER, LAWRENCE COPELAND (M) commercial engineer, miniature lamp department, Edison Lamp Works of General Electric Co., *Harrison, N. J.*

POWELSON, JOHN W. (M) works manager, Pittsburgh Model Engine Co., P. O. Box 958, *Pittsburgh, Pa.*

REDMOND, J. CHARLES (M) Eastern manager, Michigan Steel Casting Co., Detroit, Mich., (mail) 849 Drexel Building, *Philadelphia, Pa.*

REYNDERS, A. B. (M) works manager, Westinghouse Electric & Mfg. Co., East Springfield Works, *Springfield, Mass.*, (mail) 200 Buckingham Street.

ROBINSON, GEORGE E. (A) sales engineer, Mead-Morrison Mfg. Co., 125 Prescott Street, *East Boston, Mass.*

RUDICK, O. W. (J) recorder of design and engineering design changes, Continental Motors Corporation, *Detroit, Mich.*, (mail) 929 Piquette Avenue.

RUOFF, FRANK B. (A) sales manager, motor equipment division, Klaxon Co., Milwaukee and Cass Avenues, *Detroit, Mich.*

SACKSTEDER, ABNER FRANK (J) mechanical engineer and designer, Rockwood Mfg. Co., *Indianapolis, Ind.*, (mail) 10 Huggler Apartments.

SAMMIS, WALTER H. (J) instructor in electrical engineering, Columbia University, *New York City.*

SAWENS, CHARLES M. (M) chief draftsman, James Cunningham, Son & Co., 13 Canal Street, *Rochester, N. Y.*

SCHEIBNER, LAWRENCE F. (M) designing engineer, Hero Mfg. Co., *Philadelphia, Pa.*, (mail) 435 Rhawn Street, Fox Chase.

SCHON, PIERRE (A) sales representative, General Motors Truck Co., *Pontiac, Mich.*

SCHULZ, WALTER F. (M) assistant manager and chief engineer, Slick-Knox Steel Co., Pittsburgh, Pa., (mail) Slick-Knox Steel Co., *Sharon, Pa.*

SENCEBAUGH, C. K. (M) vice-president and general manager, Simplex Retrigerating Co., 603 Fisher Building, *Chicago, Ill.*

SIEGFRIED, J. B. (A) vice-president and sales manager, Auto Wheel Co., *Lansing, Mich.*

SMITH, HERSCHEL G. (M) chemical engineer, Atlantic Refining Co., 3144 Passyunk Avenue, *Philadelphia, Pa.*

SMITH, ROBERT L. (A) engineering representative, U. S. Industrial Alcohol Co., New York City, (mail) 1401 Columbia Road, N. W., *Washington.*

STANDARD STEEL & BEARINGS, INC. (Aff.) 5001 Lancaster Avenue, *Philadelphia, Pa.* Representatives: G. I. Abel, salesman; H. L. Dunbar, salesman; E. H. Neely, salesman; J. T. O'Neill, assistant sales manager; L. M. Watkin, salesman; C. B. Wisenburgh, salesman.

STODDARD, CHARLES E. (A) mechanical draftsman in charge of engineering records, tractor bearings division, Hyatt Roller Bearing Co., *Chicago, Ill.*, (mail) 5801 Winthrop Avenue.

SWANK, A. L. (A) general sales manager, Long Mfg. Co., *Detroit, Mich.*

THOMSON, PROCTER (M) chemical engineer, Sears, Roebuck & Co., Department 217, *Chicago, Ill.*

TOBIAS, STANLEY PERRY (E.S.) student, University of Michigan, Ann Arbor, Mich., (mail) 315 Telegraph Street, *Dowagiac, Mich.*

TOWNSEND, A. J. (A) vice-president and works manager, National Pressed Steel Co., *Massillon, Ohio.*

TURNER, CHARLES H. (M) chief engineer and assistant to the assistant to the president, Osgood Bradley Car Co., *Worcester, Mass.*, (mail) 17 Randolph Road.

TWITCHELL, STANLEY A. (M) instructor, Minneapolis Board of Education, *Minneapolis, Minn.*, (mail) 42 Summit Place.

UNWIN, HARRY (A) vice-president and general manager, Reo Motor Car Co. of Chicago, Inc., 1218 Michigan Avenue, *Chicago, Ill.*

VAN BRIGGLE, LILBURN HOWARD (A) president, Van Briggle Motor Device Co., 429 North Capitol Avenue, *Indianapolis, Ind.*

VAN COURT, ELIAS J. (A) Trask Garage & Welding Works, *Buhl, Idaho,* (mail) Box 682.

VAN METER, M. (M) chief engineer, Acme Motor Truck Co., *Cadillac, Mich.*, (mail) 401 Stimson Street.

VANSANT, HARRY C. (J) assistant engineer, Naval Aircraft Factory, *Philadelphia, Pa.*, (mail) 1909 Mount Vernon Street.

VESSEY, RALPH B. (A) works manager, Champion Ignition Co., *Flint, Mich.*, (mail) 2207 Avenue A.

VINCENT, EDWARD H. (M) president, general manager and engineer, Vincent C-R Steering Wheel Co., *Detroit, Mich.*, (mail) 500 Bewick Avenue.

VINCENT, JOSEPH E., Jr. (A) district sales manager, Peerless Drawn Steel Co., Room 1003, 55 Liberty Street, *New York City.*

WAGONER, VICTOR J. (J) mechanical engineer, Moreland Motor Truck Co., 1701 North Main Street, *Los Angeles, Cal.*

WELLMAN, S. K. (M) designing engineer, Van Dorn Iron Works Co., *Cleveland, Ohio,* (mail) 2105 Stillman Road.

WHITE, HARRY F. (M) salvage expert, Air Service, 230 East Ohio Street, *Chicago, Ill.*

WISSEL, ERNEST J. (A) mechanic, Highland Auto Garage Co., Fort Thomas, Ky., (mail) 309 Sixth Avenue, *Dayton, Ky.*

Book Reviews *for* S. A. E. Members

This section of THE JOURNAL contains notices of the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

DYKE'S AUTOMOBILE AND GASOLINE ENGINE ENCYCLOPEDIA. By A. L. Dyke. Published by the author, 617 Granite Building, St. Louis, Mo. Cloth, 6¼ by 9¾ in., 950 pages, 3362 illustrations.

In revising this book which is now in its tenth edition an effort has been made to cover practically every phase of the automotive industry by adding sections on airplanes and their engines, the Liberty engine, trucks, tractors and motorcycles. Practically every detail from the construction and repair of the axle to the repair of the radiator and the top is touched on. The Ford car receives special attention, a supplement printed partly in colors explaining every detail of the car. The book has been prepared with the idea of presenting in clear and simple form the principles upon which the gasoline engine and automobile are built and operated and to explain in detail all that an operator must understand to operate and care for any make of car and gasoline engine. No attempt has been made to treat the subject in a theoretical manner.

The book is divided into a number of sections dealing with the assembled automobile and parts of the running gear, the engine, carbureter, cooling, lubricating and ignition systems, electric starting and lighting systems, operation and care of the car, insurance, licenses and tires. Each of these sections is subdivided to cover individual parts. These sections are followed by a digest of troubles and the way to remedy them and a section on repairing and adjusting. In the last named information as to the equipment required for garages and machine shops is presented with estimates of the cost. Instructions on repairing and adjusting various parts of the automobile are given. Considerable useful information on how to use tools in the making of repairs and the application of oxy-acetylene welding is presented. A dictionary of automobile terms is included.